METEOR-Berichte

GATOR - German-African Training & Oceanographic Research

Cruise No. M100/2

October 4 – October 21, 2013

Walvis Bay (Namibia) – Port Louis (Mauritius)

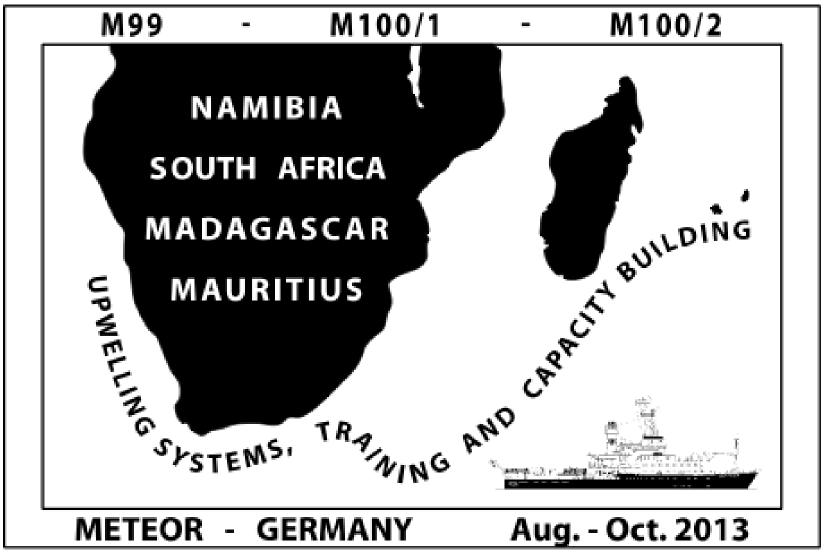

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Table of Content

1 Summary

Cruise M100/2 had four objectives: First, to resurvey hydrographic sections, second to perform comparative ecology studies, third, to explore biogeochemical fluxes and fourth, to engage in capacity building and knowledge exchange. Three study regions were visited: the Benguela upwelling regime off the coast of Lüderitz, Namibia; the Agulhas Current regime south of Port Elisabeth, South Africa; and finally the East Madagascar Current regime. The hydrographic work was based on CTD/LADCP and an underway ADCP and CTD systems. The ecology work was done with hand, bongo and multi net hauls. Underway systems were used to document biogeochemical exchanges (winds, temperature, salinity, and trace gases CO_2, CH_4, O_2, N_2O) was performed. Finally 20 students and young scientist from Germany and our collaborating African partners received training by the core senior science team and from each other. Despite some harsh weather we managed to cover all regions. However, with significantly reduced sampling in the Benguela regime. All systems on METEOR worked well.

Zusammenfassung

Die Reise M100/2 hatte vier Ziele: Erstens Wiederholungmessungen von hydrographischen Schnitten, zweitens vergleichende Ökologie, drittens biogechemische Austauschprozesse und viertens Training, Ausbildung und Wissensaustausch. Es wurden drei Arbeitsgebiete beprobt: Das Auftriebsgebiet des Benguelastromsystems vor der Küste von Namibia; das Agulhas-Stromsystem südlich von Port Elisabeth, Südafrika; und zuletzt der Ostmadagaskarstrom. Die hydrographischen Arbeiten basierten auf CTD/LACP Stationen, Schiffs-ADCP und der Unterwegs-CTD. Das Ökologische Programm basierte auf Hand-, Bongo- und Multi-Netzhols. Unterwegssysteme wurden eingesetzt, um die biogeochemischen Flüsse zu dokumentieren (Wind, Temperatur, Salzgehalt und Spurengase CO_2, CH_4, O_2, N_2O). Weiterhin erhielten 20 Jungwissenschaftler aus Deutschland und von unseren Afrikanischen Partnern Weiterbildung von den erfahrenen Wissenschaftlern. Trotz zu Teil sehr stürmischen Wetterverhältnissen konnten alle Regionen beprobt werden. Allerdings mussten die meisten Stationen im Benguela System gestrichen werden. Alle Systeme der METEOR liefen gut.

2 Participants

Name	Position/Discipline	Institute
1. Prof. Dr. Visbeck, Martin	Chief scientist	GEOMAR
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Universität Hamburg (Uni-HH)	3
Zentrum für Marine Tropenökologie (ZMT)	2
Geophysical Institute, University of Bergen, Norway (UB)	1
RSMAS University of Miami, USA	1
University of Cape Town, South Africa (UCT)	5
Nelson Mandela Metropolitan University, South Africa (NMMU)	1
Oceanographic Research Institute, South Africa (ORI)	1
Institut Halieutique et des Sciences Marines, Madagascar (IH.SM)	2

3 Research Program

The research cruise M100/2 combined hydrographic, biogeochemical, and biological studies in the context of a resurvey of three mayor current regimes in the South Atlantic and Southern Indian Ocean.

The specific scientific goals of the cruise were:

- to document multi-year time water mass, structure and transport evolution of three boundary current systems (Namibia Upwelling Regime, Agulhas Current System and East Madagascar Current)
- to study the influence of the Benguela Upwelling Systems and the tropical/subtropical front on the temporal and spatial variability of trace gas concentrations in the lower atmosphere.
- to quantify the effects of the oxygen minimum zone in the northern Benguela Current on zooplankton abundance, vertical distribution, physiology, and life-cycle strategies.
- to compare zooplankton biodiversity and community composition between the upwelling system of the Benguela Current and sub-tropical waters of the Agulhas Current and East Madagascar Current in order to teach German and African students the essential role of physical-biological interactions in determining marine productivity and pelagic processes.

A secondary aspect of the cruise was to facilitate training, capacity building and knowledge exchange with students from Germany and the South African region.

The research objectives were addressed with a range of observations on board. CTD/LADCP and plankton-net sections were carried out in three study sites. Underway systems were used during the transits between the study sites and occasionally supplemented by underway CTD measurements.

The cruise was very successful and most objectives were reached. Unfortunately the planned work on sampling for FlowSight analysis could not be carried out since the PI from the medical school from Hannover, Prof. Dr. C. Falk, had to cancel her participation. It is hoped that this can be followed up on a later expedition. All other measurements were carried out as planned with some modifications in response to weather conditions.

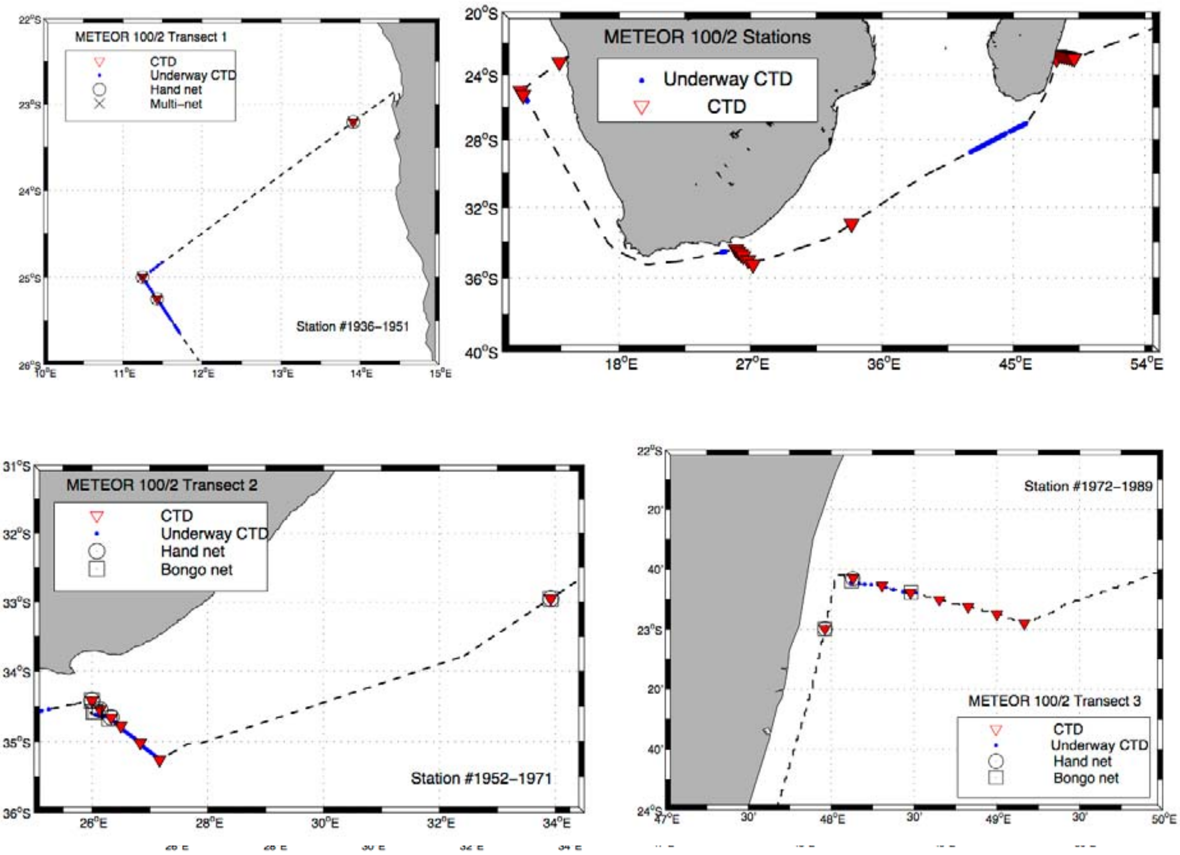

Fig. 3.1 Cruise track of METEOR cruise M100/2 with locations of CTD/LADCP stations (triangles), underway CTD (blue dot), Bongo-Net (open Squares), Multi-Net (black cross) and hand net stations (open circles).

4 Narrative of the Cruise

(M. Visbeck)

R/V METEOR departed from Walvis Bay on October 4, 2013 at 9:00 and headed southwest towards the starting point of the first CTD/multinet section at 25°S 11°15'W. A test station was successfully completed in the afternoon. The wind picked up and we decided not to try U-CTD operations during the night in poor visibility. On October 5 we began a U-CTD transect 10 miles northeast of the section starting point. The wind reached 7 Bft and the forecast tells us stronger wind is on its way. After the first CTD and multinet station we decided to reorient the section from heading east towards heading southeast against the wind but heading towards Cape Town. In the evening the wind picked up. Work on deck had to be stopped after two CTD/multi net stations. By 22:00 even U-CTD work had to be cancelled due to increasing amounts of water on deck. Until the morning of October 8 METEOR battled heavy seas and gale force winds never less than 8 Bft. Steaming speed was between 3-5 kn and valuable science / transit time was lost.

On October 10 we left the S. Atlantic Ocean and reached the Indian Ocean 50 nm south of Cape Agulhas. The wind was fair. Between October 11 10:00 and October 12 07:00 we performed a cross section to the South-East across the Agulhas current at 26.5° E. The underway measurements were enhanced with 6 CTD stations, 3 Bongo-Net hauls and U-CTD in-between stations. For the next 24 hours gale force winds from the South West prohibited any station work while on transit to Madagascar. On October 13 at 20:00 we stopped for a short CTD and Bongo net station to sample the off-shelf open ocean ecosystem. In the evening of October 15 a 24h long U-CTD section across an eddy was started. The possible location of the eddy was deduced from real time satellite sea level imagery.

On October 18 we arrived at the last sampling site east of Madagascar. At 3:00 am we took a bong net sample on the inshore side of the East Madagascar Current and from 6:00 am onwards sampled along the 22°45 S transect a total of 6 CTD casts, 2 Bongo nets and two U-CTD sections between stations. A short interruption of the ships power supply cause a one hour break in the SADCP data and computer trouble for the CTD acquisition. Fortunately the cast was almost finished (10 m upcast missing). Early in the morning on October 19 we finished the last station and began steaming towards Mauritius.

The ship arrived at Port Louis on October 21.

5 Preliminary Results

In the following a detailed account of the types of observations, the methods and instrument used as well as some of the early results are given.

5.1 Hydrographic sampling

5.1.1 CTD system and salinity

(Rafael Abel, Jenny Ullgren)

CTD-system

During M100-2 a total of 18 CTD-profiles were collected. The rosette system was installed in a Seabird Rosette System frame for 12 bottles but only 10 bottles 5 liters each were attached. See table below for sensor details. Depth profiles up to 2944m were performed; for shallower stations the full water depth was sampled. Data acquisition was done using Seabird Seasave software version 7.22.4; pre processing was done with SBE Data Processing 7.21k.

At the end of station #1982 there was a blackout in the ship's power supply. It happened during the CTD upcast at 10m depth. Fortunately all bottles were already fired and only a data loss for the remaining 10 m occurred.

At station #1953 the two U-CTD probes were attached to the CTD for calibration purposes. At station #1943 an optode from a previous glider survey was attached and during the upcast several calibration stops were included to allow for adjustment of the oxygen optode (serial # 1056).

	CTD system SBE#3
Pressure sensor	Digiquartz # 50633
T primary	# 1294
T secondary	# 5456
C primary	# 1106
C secondary	# 3960
O2 primary	SBE 43 # 1761
Fluorometer Seapoint	SCF287A
Transmissometer, Wetlabs C-Star	CST377DR

Tab. 5.1 Summary of CTD system configuration used during M100-2

CTD-conductivity calibration

The GEOMAR Guildline Autosal salinometer AS 7 was used for calibration of the primary and secondary conductivity sensor. Calibration of the salinometer was done in reference to the IAPSO Standard Seawater (P155, k_{15}=0.99981).

The standard is negatively biased for the beginning and end of the samples and positively for the time in between (Figure 5.1).

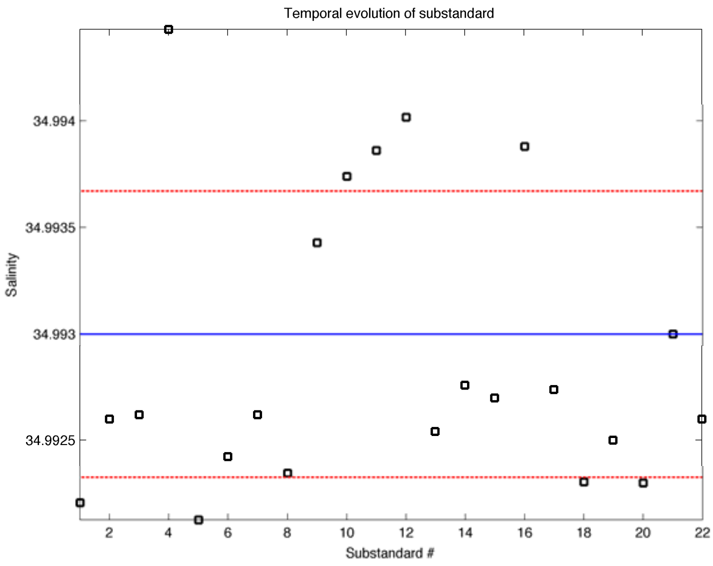

Fig. 5.1 Evolution of the substandard measurements

Overall 84 calibration points were obtained. As a kind of outlier removal, the 33% largest differences between CTD and bottle samples were discharged and not considered for calibration. The projection from the bottle stop of the up- to the downcast was done by searching for similar potential temperatures within 30dbar pressure internal around similar pressure horizons between up- and downcast. For the critical loop edit velocity 0.01m/s were used. The final CTD data set is composed from the secondary set of sensors. This was done because of a slightly lower RMS residual of the respective sensor set after calibration.

The conductivity calibration of the downcast data was performed using a 1st order linear fit with respect to temperature, pressure and conductivity.

	CTD system SBE#3
Sensor pair used for calibration	2
RMS misfit after calibration - salinity	0.0068
Polynomial coefficients - conductivity	Offset: 0.012879 P1: 3.2344e-08 T1: 0.0028296 C1: -0.034719
Pressure sensor correction (decks-offset)	1.925

Tab. 5.2 End of cruise salinity and pressure summary of calibration information for the CTD systems used during M100-2.

Oxygen calibration

The CTD oxygen downcast for CTD systems is calibrated by using 67% of the joint data pairs between downcast CTD sensor value and titrated oxygen (Section 5.1.2). For the calibration a linear correction polynomial depending on pressure, temperature and the actual oxygen value was fitted. Hence, a total amount 112 data points for CTD system SBE#3 was recorded, which results in an RMS-misfit of order 1.08 µmol · kg^{-1} for the primary SBE43.

	CTD system SBE#3
Sensor pair used for calibration	2
RMS misfit after calibration - oxygen	1.08
Polynomial coefficients - oxygen	Offset: 5.5179 P1: 0.0010096 T1: 0.1882 O1: 0.042238

Tab. 5.3 End of cruise oxygen summary of calibration information for the CTD system used during M100-2.

5.1.2 Oxygen titration

(Jonathan Durgado, Tim Rixen)

A total of 112 discrete water samples were taken from selected depths for oxygen measurements by Winkler titration. Samples were taken with ~100 ml WOCE bottles with well-defined volumes from a majority of the CTD rosette casts in order to calibrate the SBE43 oxygen sensors attached to the CTD. It was ensured that the sample bottles were flushed with at least 3 times its volume and the samples were free of air-bubbles. At most CTD casts, a duplicate from one of the Niskin bottles was taken in order to quantify sampling and titration uncertainties. Oxygen was determined by Winkler titration within 12 hours after sampling following standard protocols (Langdon, 2010).

An additional 46 water samples were taken from the ferry box system to calibrate the underway oxygen sensor.

The precision of the Winkler-titrated oxygen measurements (1σ) was 0.13 ml/l (5.67 µmol/l) based on 26 duplicates and 1 triplicate.

5.1.3 Hydrographic results

The data from this cruise will mostly be used to compare them to earlier and later expedition. As an example the water mass property distribution for the three main study regions is shown in Figure 5.2.

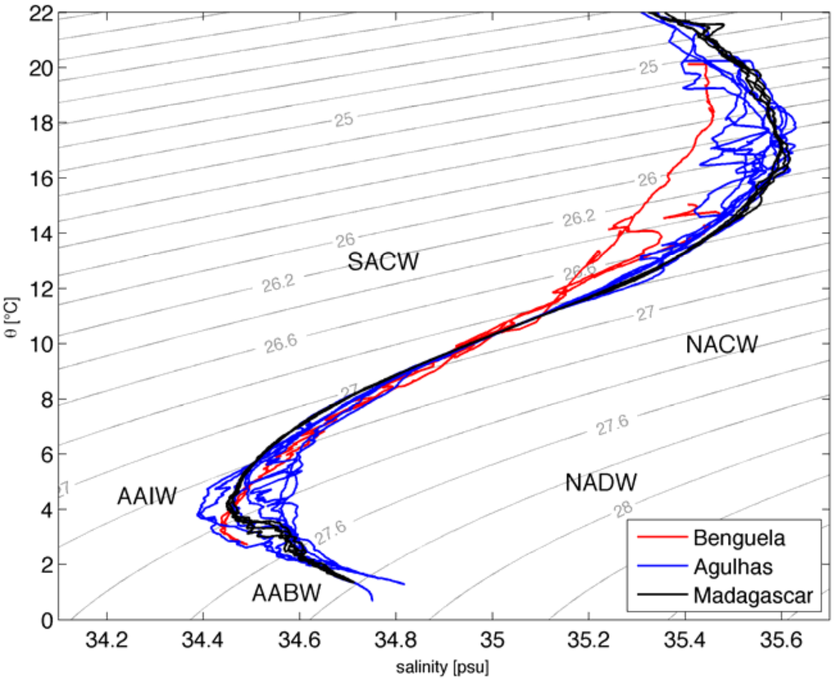

Fig. 5.2 T-S diagram for the three different sections

5.2 Current observations

5.2.1 Vessel mounted ADCP

(Jefim Vogel, Martin Visbeck)

Current measurements were performed continuously throughout the whole cruise, using the two vessel mounted RDI Ocean Surveyor (OS) instruments (38kHz and 75kHz) of R/V METEOR. Both instruments worked flawlessly for the entirety of the cruise and produced good data.

The OS38 ADCP was mounted in the moon pool at an angle of zero degrees (relative to the ship's center line) whereas the OS75 one was mounted at an angle of 45 degree relative to that in order to avoid interference between the two. Calibration points on CTD stations were used in order to determine each instrument's misalignment angle that was then taken into account in the data processing. We applied suggested misalignment angles of -0.278° for the OS38 and -1.055° for the OS75. Both instruments were run in narrowband (NB) mode, OS38 using 32m bin size and OS75 using 8m bin size. Depending on the region and sea state, the ranges covered by the instruments differed between 500-1100m for OS38 and 550-750m. The instruments were programmed to ping at a rate of 2-3 seconds for OS75 and 3-4 seconds for OS38.

VMADCP data was recorded continuously with only two minor gaps: one gap of about an hour due to problems with the server connection and clock synchronization on October 4th (which also accounts for the very short files #001 and #003), and another gap of about an hour due to two short electric black outs during the East Madagascar section on October 18th (which also accounts for the very short files #022, #023 and #024). Fortunately, it seems that apart from the gap itself, no data was lost during the black outs.

Data quality was fine during most of the cruise. However during the two storms we encountered on this cruise, range and data quality were considerably reduced, affecting mostly the OS38 whereas OS75 was still largely OK (see the lower variance in range), possibly due to their different positions at the ship's hull. Similarly, range and data quality were also reduced during CTD stations, which probably is due to the use of thrusters. Furthermore, we noticed a pronounced change in the instruments' ranges (again particularly in the OS38) between the South Atlantic and the Indian Ocean, with considerably lower ranges in the South Atlantic, which might be due to the Benguela upwelling system and the associated high productivity.

Some interference with other high frequency instruments was evident from the instruments' target strength data but seemed to be unproblematic. According to the bridge, the only high frequency instrument used during the cruise was the 12 kHz EM122 multi-beam echo sounder that hadn't interfered with the VMADCPs on earlier cruises.

VMDAS software was used to configure the ADCPs and to record the VMADCP data as well as the ships navigational data. Data conversion and processing was performed using the GEOMAR Ocean Surveyor Sputum Interpreter (OSSI) software package for Matlab, version 1.7 (OSSI 17).

5.2.2 Lowered ADCP sampling

(Jefim Vogel, Martin Visbeck)

LADCP data was collected on most of the CTD casts, giving a total of 16 profiles, including 1 shelf cast (130m), 3 shallow open ocean casts (1x190m, 2x1000m), 8 mid-depth casts over the oceanic rise (2000m) and 4 bottom-casts over the oceanic rise (1530-2870m).

Two ADCP-units, one up-looking and one down-looking, were mounted within the CTD-rosette with especially manufactured frames, protecting the instruments and giving free way for the acoustic beams. Both ADCP-units were connected to one CTD-mounted battery-pack which also served as a data interface for cable connection between the casts. The energy consumption of the two-ADCP-unit setup was moderate and required replacement of Alkaline batteries only once, after about 12500m of cumulative one-way profile depth. The ADCPs were configured and run using GEOMAR shell scripts in a virtual Linux environment.

The measurements were run in a master-slave-setup of two 300 kHz RDI Teledyne Workhorse ADCPs, SN 6468 as down-looking master, SN 11461 as up-looking slave. Both instruments were run in single-ping mode using 25 bins of 10m lengths. The ping time was set to 0.9s and the ensemble time to 1.5s. Mode 1 ambiguity velocity was set to 250 cm/s. Blank after transmit was 0m was the down-looking master and 8m for the up-looking slave.
This configuration (which was adopted from GEOMAR M98 cruise) produced good results for all casts and was hence maintained throughout the entire cruise. However, internal bottom track processing was unfortunately not enabled, so bottom tracks were calculated as part of the external processing. This should be improved for future cruises.

While the ADCPs themselves worked fine throughout the cruise, we had some problems with the connection and communication between the instruments and the LADCP control computer for casts #004 and #005. Because of this, neither unit could be started for LADCP cast #004, so there is no data for that cast. For cast #005, we tried to start the units manually using WinSc software instead of the shell scripts in the Linux environment, which worked out for the down-looking master, but not for the up-looking slave.

All data was processed on board using GEOMAR/LDEO LADCP processing software for Matlab, Version 10.18, which includes both shear and inversion methods to derive an absolute velocity profile (Visbeck 2002; Thurnherr 2010). In the processing, the respective pre-processed CTD data as well as navigation data and processed velocity data from the RDI Teledyne 38kHz VMADCP are used as constraints. One cast #005 suffered from large tilt on the upcast. This was caused by the rather large ship drift in the Agulhas current core.

5.2.3 Exemplary Results

ADCP profiles were used for transport estimates of the Agulhas and the East Madagascar boundary current systems. First results can be seen in figure 5.3, where VMADCP data was merged with LADCP data in order to produce cross-sectional velocities for the Agulhas current south of Port Elisabeth.

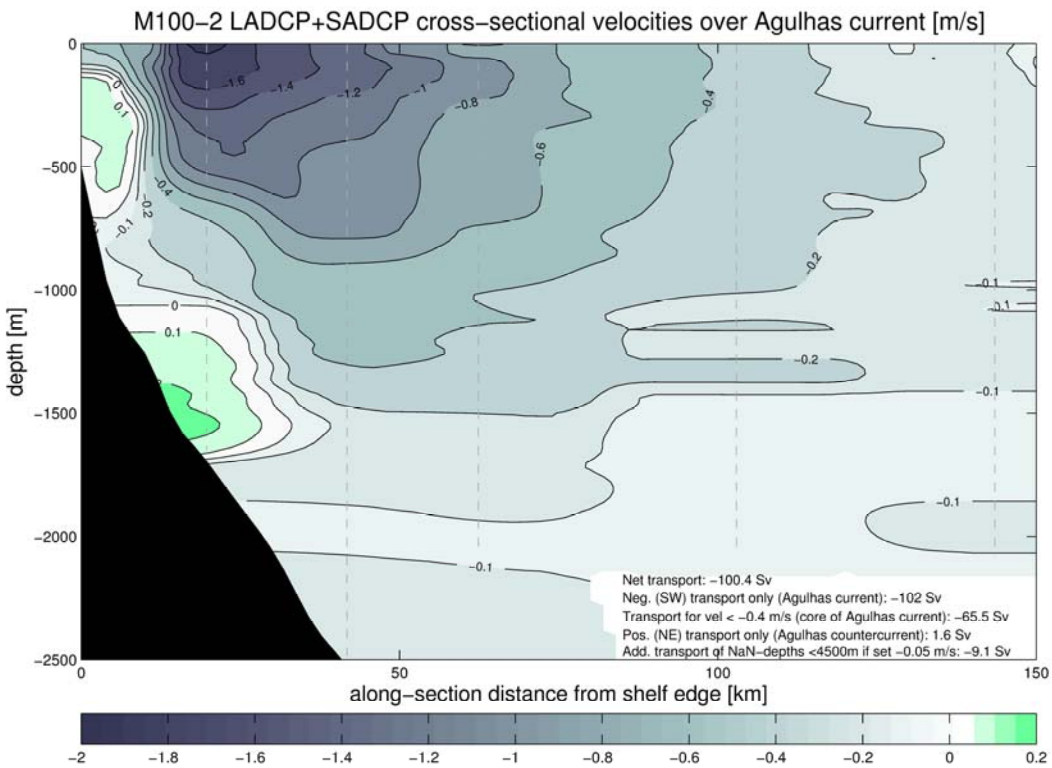

Fig. 5.3 Agulhas section: Velocities of the Agulhas current as measured on October 11th /12th, 2013 on Meteor M100/2 during the transect from 34°25.2' S, 26°00.0' E to 35°15.6' S, 27°10.0'E. Shown are merged velocities measured by VMADCP and LADCP systems, rotated parallel to bathymetry (hence parallel to the stream), using an angle of 30°. Net transport over the whole section was -100 Sv. Negative (SW) transport only (Agulhas current) was -102 Sv. Negative (SW) transport for velocities < -0.4m/s (core of Agulhas current) was -66 Sv. Positive (SW) transport (Agulhas countercurrent) was +1.6 Sv. Estimated uncertainty for deep velocity not covered by measurements would be 9 Sv assuming typical speeds of 0.05 m/s.

Analogously, VMADCP and LADCP from the East Madagascar CTD-section were merged into a to-depth 2D-image of cross-sectional velocities of the East Madagascar current (figure 5.4).

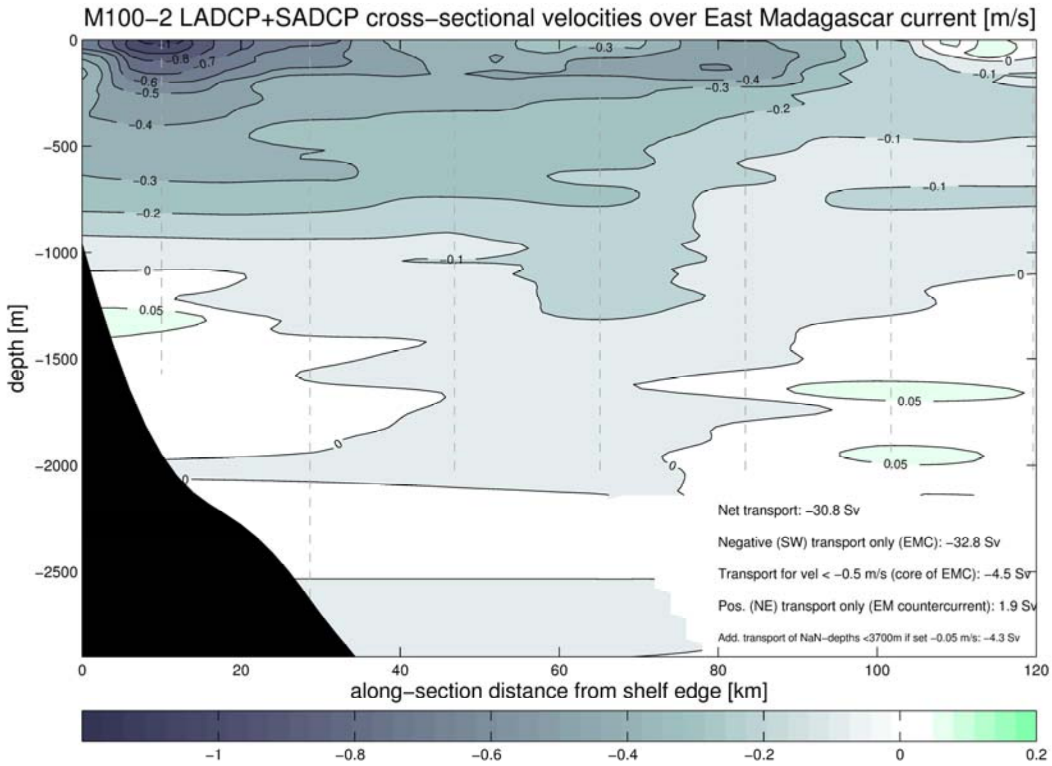

Fig 5.4 Caption East Madagascar section: Ocean velocities of the East Madagascar current as measured on October 18th/19th, 2013 on Meteor M100_2 cruise during a CTD section from 22°41.7' S, 48°02.0' E to 22°58.0' S, 49°10.0'E. Shown are merged velocities measured by VMADCP and LADCP systems, rotated parallel to maximum flow, using an angle of -30°. Note that maximum flow is not parallel to bathimetry (roughly -10°), which implies anomalous flow at the time of measurements.
Net transport over the section is -30.8 Sv;
Negative (SSW) transport only (Agulhas current) is -32.8 Sv;
Negative (SSW) transport for velocities < -0.5m/s (core of East Madagascar current) is -4.5 Sv.
Positive (SW) transport (Agulhas countercurrent) is +1.9 Sv.
Projected additional transport if velocity was -0.05 m/s in all depths (<3700m) not covered by measurements would be -4.3 Sv.

Model-Data Comparison

Throughout the cruise, data collected were compared with a high-resolution ocean model of the greater Agulhas region, INALT01 (Durgadoo et al. 2013). This provided the opportunity for comparative assessments of the model (identify potential biases). Furthermore, the model output allowed the observations to be placed in a wider context of mesoscale to interannual variability of the Agulhas Current system.

Temperature and salinity profiles, taken at the positions of the CTD casts, showed a good structural correspondence within the expected range of mesoscale, seasonal and interannual variability. They also allowed the identification of small model offsets, e.g. a too low salinities in the Antarctic Intermediate Water range.

The modeled velocity section across the Agulhas Current (Figure 5.5) is comparable in structure and magnitude to the measured values (obtained from the ship-borne and lowered ADCP). Velocities are strongest at the surface (more than 1.4 m/s) and closely aligned to the continental slope. The 0.2 m/s isotach reaches down to 1500 m depth and far offshore, resulting in a large volume transport of the order of 100 Sv. Also seen is an indication of a countercurrent at depth. As in the observations, it remains to be analyzed if this is a core of the northward flowing Agulhas Undercurrent (Beal 2009), or rather an imprint of recirculation dynamics (Biastoch et al. 2009).

It has to be mentioned that the INALT01 model is not an operational model, but rather a hindcast simulation under past atmospheric conditions (1948-2007). Thus, the model snapshot shown above is not taken at the exact time of the measurements, and represents only a similar stage in the expected range of variability.

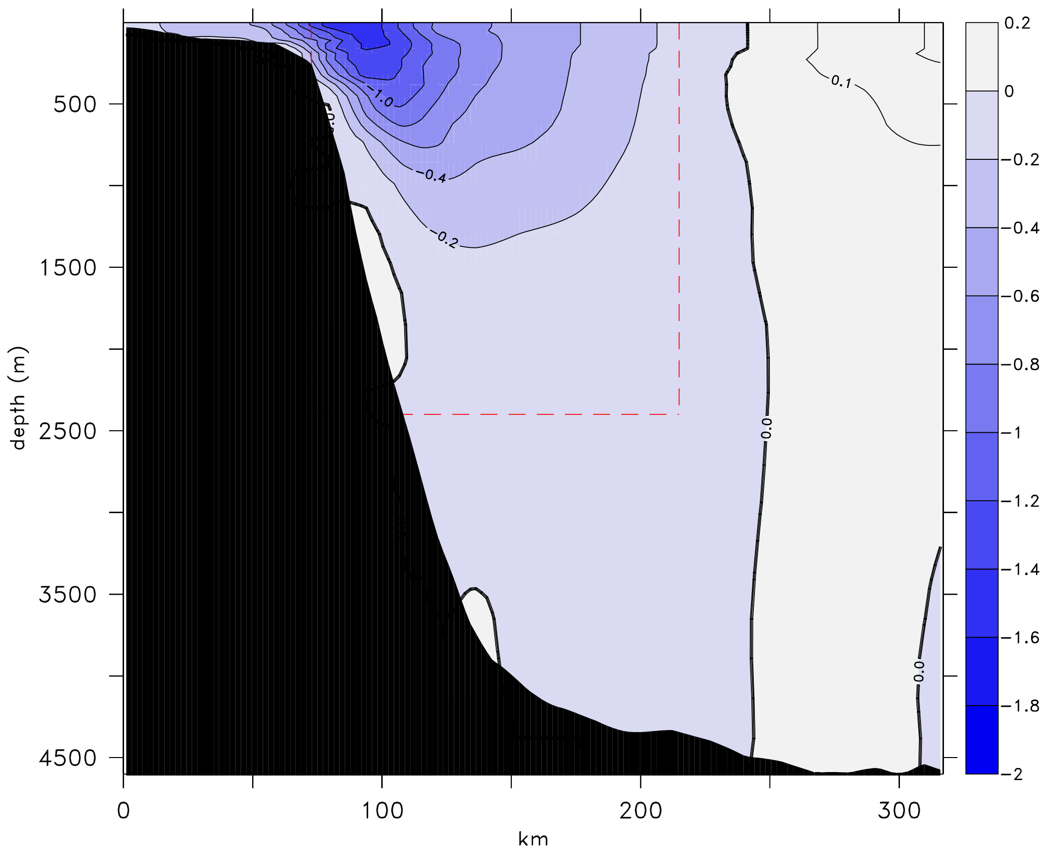

Fig. 5.5 Velocity section [m/s] off Port Elizabeth in the INALT01 model (snapshot of 5-day average centered at 15 Aug 2007). Indicated by the red dashed line is the area covered by the ADCP measurements. Total southward transport of the section is 100 Sv in remarkable agreement with the observations.

Multi Parameter underway Eddy-Survey

VMADCP and at times also U-CTD data were used to document eddy and filament structures along the cruise track, which was of interest both for underway biogeochemical analyzes of along-track surface water and for analyzing the fine structures of East Madagascar eddies. Figure 5.6 shows along-track VMADCP velocity vectors (a), zonal and meridional velocities (b) and U-CTD temperature data (c) of an anticyclonic eddy that we crossed south-west of Madagascar.

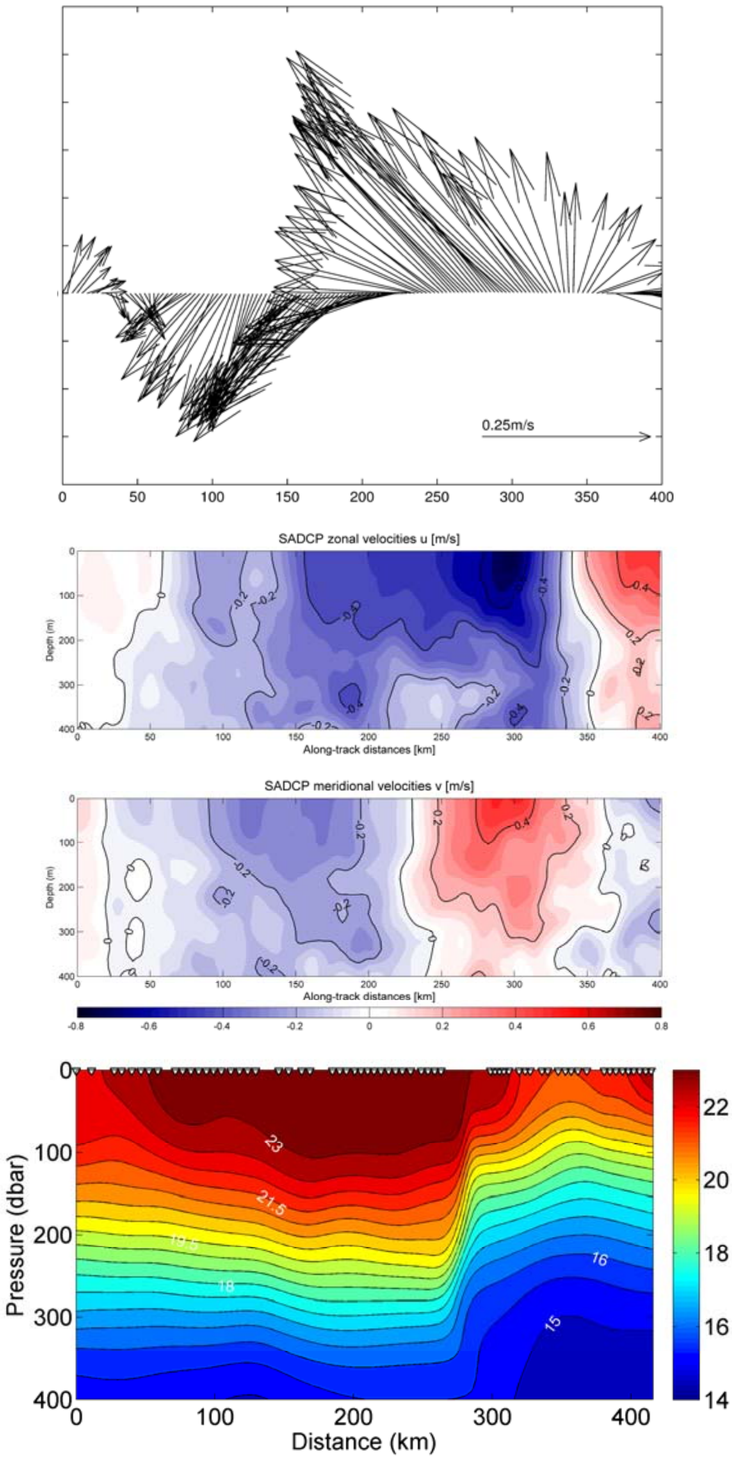

Fig. 5.6 Ocean velocities and temperature [°C] of an anticyclonic EMC eddy as measured on October 15th /16th, 2013 and U-CTD-section southwest of Madagascar, between 28°43.8' S, 42°04.1° E and 27°01.0' S, 45°47.4' E (see Fig 3.1 for track position).

Shown are vectoral (a) as well as zonal and meridional (b) VMADCP velocities and U-CTD temperatures (c) plotted over along-track distance. Salinity was also measured by the U-CTD, but UCTD #1 exhibited very noisy data that suggested that the sensor was damaged. The eddy was almost triangular in shape, which explains the extraordinary abrupt flow and temperature pattern in the eastern part of the eddy between kilometer 250 and 320.

5.3 Biological sampling

5.3.1 Zooplankton ecology and ecophysiology

(Holger Auel, Anna Schukat, Stephanie Simon, Flavia Höring, Patricia Kaiser, Nadine Strydom, Maggy Reddy, Nina Lester)

MultiNet deployment

MultiNet hauls were carried out at three stations in the Benguela Current upwelling system off Namibia (Table 5.4). A HydroBios MultiNet Midi with 0.25 m^2 mouth opening, five separate nets, and 200 µm mesh size was deployed vertically down to a maximum sampling depth of 800 m. Sampling intervals were chosen according to hydrographic conditions obtained from CTD casts immediately before the MultiNet deployment. Usually, one or two depth intervals were sampled below the intermediate oxygen minimum zone (IOMZ), one coinciding with the IOMZ, and one or two above the IOMZ taking into account the depth of the mixed layer and the location of the chlorophyll maximum.

At the first station 1938, the zooplankton community was dominated by the copepod *Calanoides carinatus*, as characteristic for an active upwelling system. The other two Multinet stations 1945/1946 (two casts at the same location) and 1950 were located further offshore over >4000 m water depth. Phytoplankton and zooplankton biomass as well as secondary production were lower than at the first station. Zooplankton was particularly scarce at mesopelagic depth coinciding with the IOMZ.

Bongo deployment

A total of seven stations were sampled by Bongo net hauls in the region of the Agulhas Current and off the east coast of Madagascar (Table 5.4), mainly to collect fish larvae and spiny lobster phyllosoma larvae. The Bongo net (two times 60 cm mouth diameter, 300 and 500 µm mesh size, respectively) was used for double-oblique hauls to a maximum sampling depth of 310 m. Maximum sampling depth was calculated from wire length and angle, while the effective volume of water filtered was measured with a flowmeter (HydroBios, Kiel, Germany) attached to the 300 µm net. The net was deployed at 2 kn steaming speed of the vessel through the water, and the wire was paid out with 0.5 m s^{-1}, resulting in a net speed of ca. 0.5 m s^{-1} through the water during the down cast. At maximum depth, the vessel reduced its steaming speed to 1 to 1.5 kn through the water, while the net was hauled in at 0.3 m s^{-1}, resulting in a speed of the net of 0.8 to 1.1 m s^{-1} through the water.

The first Bongo netstation 1955 on the Agulhas Bank was characterised by a large amount of filamentous algae, many fish eggs and some copepod species, typical of neritic ecosystems, e.g.

Calanoides macrocarinatus and *Temora*. Primary and secondary productivity were apparently high.

At the second Bongo net station 1985 in the centre of the Agulhas Current, high current speed and drift were too strong for a planned deployment of the Bongo net. Instead two surface tows at ca. 7m depth were conducted and provided a rich collection of tropical neuston species including pontellid copepods and a few specimens of pelagic fish larvae, mainly Barracuda larvae and an isolated late stage Grouper larva.

Station 1962 at the offshore margin of the Agulhas Current was sampled during night-time and, hence, provided high abundances of vertically migrating euphausid shrimps and several small mesopelagic fish such as lantern fish and bristle mouths. In contrast, copepods were comparatively scarce and mainly represented by the family Eucalanidae.

The final Bongo net station off south-eastern South Africa 1971 was located further offshore in colder (18.2°C) and apparently very productive waters. Besides a large amount of filamentous algae, many euphausids, many fish larvae of different species, dominated by Clupeidae, many copepods, and two large decapods shrimps were caught.

The last three Bongo net stations were sampled off the east coast of Madagascar on October, 18th (Table 5.4). Station 1976 was located at the shelf break over 452 m water depth and revealed a relatively poor plankton community consisting mainly of copepods, meroplanktonic larvae, and some fish larvae including two leptocephalus larvae. Despite night-time sampling, almost no vertically migrating species were present. Both, station 1979 over the continental rise (bottom depth 1457 m) and the offshore station 1984(bottom depth > 3500 m) had even less zooplankton. The samples consisted mainly of small copepods. Despite increased effort (i.e. towing the Bongo net for additional time at certain depths), no phyllosoma larvae of spiny lobsters were caught, which initially was one of the main intentions of the sampling programme off Madagascar.

Measurement of copepod egg production

The measurement of copepod egg production is an established standard method to assess secondary production. Adult female copepods were sorted from the catches immediately after the nets came back on board and placed separately in small dishes (cell wells). They were kept in darkness and at simulated *in situ* temperature in a refrigerator for 24 hours. After that, the number of eggs was counted which each female had produced. Minimum and maximum data are presented as eggs per female and day for each station in Table 1. Copepod egg production within the first 24 hours after the catch is considered representative for *in situ* conditions.

Respiration measurements with copepods on board

The respiration rate of copepods was measured on board by means of a 10-channel optode respirometer (PreSens, Regensburg, Germany). Two sets of experiments were conducted in order to (i) establish the impact of hypoxic conditions on copepod respiration and (ii) to assess the effects of ambient temperature on copepod respiration. Individual copepods were placed in small bottles (ca. 10 ml volume) and kept in a water bath in a refrigerator. The oxygen concentration was monitored continuously and non-invasively by optode respirometry. Eight individuals were measured in parallel together with two animal-free controls. The respiration rate was calculated as reduction of oxygen saturation over time. Only preliminary results were obtained during the cruise, since oxygen saturation will have to be converted to oxygen concentration and copepod dry mass will have to be measured in the home laboratory in order to calculate mass-specific respiration rates. After the experiments, copepods were deep-frozen at -80°C.

Station	1938	1945/1946	1950	1955	1958 (2x)	1962
Net type	MN vertical	MN vertical	MN vertical	Bongo oblique	Bongo surface sample	Bongo oblique
Sampling depth [m]	150-0	800-0	800-0	230-0	ca. 7-0	310-0
Bottom depth [m]	156	4017	4030	463	1630	2400
SST [°C]	12.5	15.5	15.9	19.2	22.1	22.1
Fluorescence integrated over upper 120 m [relative units]	193	54	69	211	87	47
Copepod egg production [fem.$^{-1}$ day^{-1}]	low, 0 to11	no females at surface, mesopelagic species did not produce eggs	no females at surface, mesopelagic species did not produce eggs	high, 2 to 77	high, 0 to 86	only eucalanid copepods present, which did not produce eggs
Filtered volume [m^3]	5 x 7.5	9 x 10 to 50	5 x 30 to 60	546	166	592
Zooplankton biovolume	relatively high	< 50 ml low, very low at mesopelagic depth	< 50 ml low, very low at mesopelagic depth	> 400 ml, very high, but mostly filamentous algae	ca. 50 ml, comparatively high	ca. 100 ml, high
Species composition	*Calanoidesca rinatus*, other copepods	some, partly deeper living copepod species, e.g. *Candacia*, *Pleuromamma*, *Aetideopsis*, pontellid copepods	some, partly deeper living copepod species, e.g. *Pleuromamma*, *Paraeuchaeta*, *Euchirella*, pontellid copepods	very many filamentous algae, some typical shelf-species such as the copepods *Temora* and *Calanoidesm acrocarinatus*, very many fish eggs, larvae mostly of Clueidae and Myctophidae	pontellid copepods, *Calanoidesmacr ocarinatus*, eucalanid copepods, some pelagic fish larvae (Sphyraenidae, Barracudas and Serranidae, Groupers)	only few, mainly eucalanid copepods, many krill of at least two species, some mesopelagic fish, e.g. lantern fish and bristle mouths as well as Clupeidae and Myctophidae
Conclusions	species composition typical of coastal upwelling system, but secondary productivity low	almost oceanic, subtropical offshore station, low productivity.	almost oceanic, subtropical offshore station, low productivity.	extremely high phyto-plankton concentra-tion; highly productive Agulhas Shelf ecosystem	typical tropical surface sample with neuston and pleuston species. Regular net deployment was impossible due to strong Agulhas Current.	typical tropical night-time station with diel vertical migrators at the surface

Station	1971	1976	1979	1984
Net type	Bongo oblique	Bongo oblique	Bongo oblique	Bongo oblique
Sampling depth [m]	200-0	200-0 10 min towed at 147 m and 15 min towed at 14 m	200-0 5 min towed at 180 m and 10 min towed at 14 m	141-0
Bottom depth [m]	3984	452	1457	> 3500
SST [°C]	18.2	24.4	24.4	22.8
Fluorescence integrated over upper 120 m [relative units]	149	46	28	22
Copepod egg production [$fem.^{-1}$ day^{-1}]	variable to high, 0 to 68	not analyzed	not analyzed	not analyzed
Filtered volume [m^3]	457	598	456	404
Zooplankton biovolume	ca. 200 ml, very high	intermediate	low	very low
Species composition	many filamentous algae, many copepods, e.g. *Calanoidesm acrocarinatus*, many pteropods, very many krill, very many clupeoid fish larvae, salps, two large decapod shrimps	some filamentous algae, some copepods, a diverse group of fish larvae including two leptocephalus stage eel larvae, an isolated specimen of the sunfish *Mola* sp., several meroplanktonic larvae of brachyuran crabs	some filamentous algae, some small copepods, including the tropical, epipelagic *Euchaeta marina*, few fish larvae	mainly small tropical copepods, some gelatinous zooplankton and a few fish larvae in early stages of development
Conclusions	very productive, definitely not a tropical oceanic oligotrophic situation	relatively poor plankton community on the eastern Madagascar shelf. Despite night-time sampling, only few vertically migrating species	poor zooplankton community typical of oligotrophic tropical/ subtropical oceanic systems	poor zooplankton community typical of oligotrophic tropical/ subtropical oceanic systems

Tab. 5.4 Station data, preliminary results, and conclusions of the zooplankton sampling programme during cruise leg M100/2.

5.3.2 Ichthyoplankton studies

Ichthyoplankton sampling was undertaken by Dr. Nadine A. Strydom, Nelson Mandela Metropolitan University (NMMU). Research interests for the cruise were to collect larval fishes using Bongo nets in the upper 200 m of the water column at 34°S 26°E, in the waters of warm temperate South Africa. Opportunities to sample ichthyoplankton in this region are rare and the dynamics of ichthyoplankton in this region of the Agulhas Current is poorly known. Of particular interest was the species composition and species origins (coastal, nearshore, pelagic, mesopelagic, bathypelagic), species densities and reference specimens to aid identification for the ichthyoplankton research group at NMMU.

Unfortunately, due to severe weather, this component of the research cruise had to be adjusted. In order to undertake limited Bongo sampling, the transect was moved westwards and limited to only two full Bongo tows (0-200 m), one subsurface tow (0-7 m) in the Agulhas Current region. An additional offshore tow (0-200 m) was conducted outside of the Agulhas Current region. With limited data, reference specimens were collected and will be included in the ichthyoplankton reference collection at NMMU to aid students with identification.

Detailed identification will take place at NMMU where higher powered microscopes and a full literature base for larval identification are available. Some preliminary findings from the Bongo tows include an abundance of larvae belonging to the Order Clupeiformes, particualry Family Clupeidae. These are common planktivorous, pelagic species with pelagic eggs. The Order Myctophiformes, Family Myctophidae were also abundant in samples. Lantern fishes are meso- and bathypelagic, also epibenthic, and undertake vertical migration at night to the upper 200 m of the water column where they feed on zooplankton. Despite their ubiquitous occurrence, densities were low. Many larger specimens occurred in very low densities; often only single individuals were collected. However, important reference specimens for the following fish families have been collected on the cruise and will make a significant contribution to the identification reference base used by students at NMMU:
Families Gobiidae, Bregmacerotidae, Carangidae, Chauliodontidae, Molidae, Serranidae (*Epinephelus),* Sphyraenidae (Sphyraena).

The continental edge at 34°S 26°E also proved to be an important spawning area for fishes as was evidenced by the large numbers of a variety of fish egg types within the filamentous algal layer sampled in this area. This warrants further investigation in to the productivity of shelf edge waters and the value of this for fish spawning.

5.3.3 Hand-Net

(Valerie Menke, Saskia Horstmann)

A Handnet with a diameter of 18cm and a mesh size of 50µm was carried out at nine stations off the coast of Namibia and South Africa and Madagascar. Research interest was to collect surface water dwelling planktonic foraminifera to study the influence of CO_2 concentration, pH variation on foraminifera diversity and changes in Sea Surface Temperature and Sea Surface Salinity on the fauna composition. The net was lowered to 30m water depths and lifted with a constant speed of 0.5m/s. After rinsing the walls of the net in order to remove remaining foraminifera tests, surface water samples were filled into plastic bottles and stored at 10°C. Individual foraminifera tests were selected under the microscope and identified. Individuals to small to be identified using the equipment on the ship were counted as "unknown" species (table 5.5).

Surface samples from the Benguela coastal upwelling system mainly consist of species adapted to temperate water temperatures (*G.siphonifera, G.inflata, G.ruber*) but also show counts of *G.bulloides* as typical cold water species. Opposed to that, stations off the coast of Madagascar show higher numbers of tropical species such as *G.sacculifer* and *O.universa.* The diversity was calculated using the Shannon Wiener Index H(s) and varies along the cruise track without a clear correlation between geochemical parameters and diversity.

Difficulties during sampling especially strong surface currents keeping the handnet in a rather horizontal position however possibly biased the sampling depth and therewith the dataset (this especially influenced sampling of station 1954).

Station	#Forams total	*G. siphonifera*	*O. universa*	*N. dutertrei*	*G. bulloides*	*G. inflata*	*G.sacculifer*	*G. ruber*	*G. menardii*	Unknown	CO_2 Horst (ppm)	pH (FerryBox)	SSS (DSHIP)	SST (°C, DSHIP)	H(s)
1935	17	3	1	5	3	0	0	0	0	5	576		34.9	13.3	1.13
1943	19	3	0	0	4	3	0	3	0	6	406	8.02	35.2	15.9	1.20
1949	18	2	2	0	2	4	0	4	0	4	389	8.03	35.4	16.3	1.40
1954	0	0	0	0	0	0	0	0	0	0	364	8.08	35.4	21.2	0
1056	6	3	1	0	0	0	0	2	0	0	372	8.08	35.4	22.5	1.01
1960	13	4	1	0	0	2	0	4	2	0	378	8.08	35.4	22.4	1.49
1969	4	2	0	0	0	0	0	0	0	2	358	8.07	35.5	18.7	0.34
1975	11	0	1	0	0	4	2	2	0	2	384	8.09	34.9	24.7	1.20
1978	8	0	1	0	0	1	2	3	0	1	385	8.09	34.9	24.8	1.23

Tab. 5.5 Station number and counts of different foraminifera species and diversity (H(s)) compared to measured CO_2, pH, SSS (uncalibrated) and SST.

5.4 Underway system

Several under-way systems were used throughout the cruise.

5.4.1 Underway CTD system

(Jenny Ullgren, Andreas Pinck)

An Oceanscience UCTD 10-400 system was used during the cruise to make measurements of upper ocean temperature and salinity while underway. The system consists of a CTD probe with a tail spool on which the desired length of line is spooled on using a rewinder. The probe free falls through the water column, sampling temperature, conductivity and pressure at 16 Hz during a pre-set time interval. Deployment and recovery of the probe are done using a winch and small davit that form part of the UCTD system. Data are recorded internally and uploaded via Bluetooth connection.

Two probes, SN 068 (probe-1) and SN 155 (probe-2), were used alternatingly on the UCTD transects, each a few hours at a time; while one probe was in use, the other had its memory read and battery re-charged. A total of 129 UCTD casts were completed during the cruise. Most of the profiles (54 casts) were done to a target depth of 200 m (200 m line spooled on, free-fall time of 50 s), 29 to a target depth of 300 m, 27 to a target depth of 400 m, and the remainder to 100 m or other target depths. The depth reached by the probe varied but was generally within about 15 m of the target depth (overshoots were larger, ~20 m, in the early casts of the cruise and ≤10 m towards the end, indicating the importance of operator skill).

Initial processing of UCTD data was done using SBE Data Processing, Version 7.21 k, following a procedure used during an earlier METEOR cruise (M99). This basic processing included adjusting for sensor delay between temperature (T) and conductivity (C) sensors relative to pressure (P). The value by which to advance T or C in order to align parameters in time was explored experimentally and an adjustment of +0.08s for T was selected (based on one cast, so far). Salinity, potential temperature and density were then derived from the measured variables. Data were then averaged into 1 dbar bins. Only data from the down casts were included, since the reeling-in phase of the cast was found to be very spiky. Further processing, done in Matlab, involved matching the time stamp of the start of the cast, as recorded by the instrument, with the DAVIS Ship-data record to get the position of the cast.

A calibration cast was performed with both UCTD probes attached to the rosette during a regular CTD cast to 300 m depth and the data will be used to obtain a final calibration of the system.

During the course of the third UCTD transect we noticed that conductivity data from one of the probes, serial number 068, were bad, with very severe spiking and also an increasing offset. The probe was inspected and it was found to have sustained some serious damage, with visible chipping of the probe head which was linked to damage of the conductivity cell. None of the operators had noticed this while operating the UCTD. The broken probe was taken out of service. Parts of the conductivity record from probe 068 must be discarded but from some profiles the problems (like spikiness) in the conductivity might be possible to resolve with thoughtful post-processing. The temperature record from probe 068 is not affected. From probe SN 155, both temperature and conductivity measurements appear to be of good quality. A total of 49 casts were completed with probe 068 and 80 with probe 155.

The 6th to 9th profile (cast # 025-028) with probe 068 had significant spikes in the upper ca 50 m. The 19th profile (cast # 047) showed a relatively strong spike and possible positive bias below, also seen in some following profiles. Profile 26 with probe 068 (cast #71) on 15-Oct-2013 and following profiles showed a strong deterioration with very severe spiking, and from the 40th profile (cast #101) onwards there is a very large offset in conductivity.

Other problems with the UCTD system encountered during the cruise included a technical fault in the winch controller of the first winch used (belonging to the University of Hamburg) after the severe weather early on in the cruise, which exposed the winch to large amounts of spray. It was replaced by a second winch (belonging to GEOMAR), which worked without problems for the remainder of the cruise. The GEOMAR winch got a new motor at the beginning of this cruise. Once, the line got badly tangled on the tail spool during a cast and about 500 m of line had to be cut. In another incident, the line tore but was caught in the level wind so that, fortunately, the probe could still be retrieved. Smaller issues included some difficulty in separating the tail from the probe. This was resolved by clearly marking the range of motion of the twist-and-lock mechanism, to avoid turning the pieces too far. It was also found that low battery levels could cause a problem for the Bluetooth connection; in such cases, connecting the charger enabled communication.

A second power supply that was brought as a spare failed during its first use.

Preliminary results
Four UCTD transects were done: in the Benguela system, across the Agulhas current, crossing an eddy south of Madagascar, and finally across the East Madagascar Current (Fig. 3.1). The temperature profiles from each section are shown in Fig. 5.7.

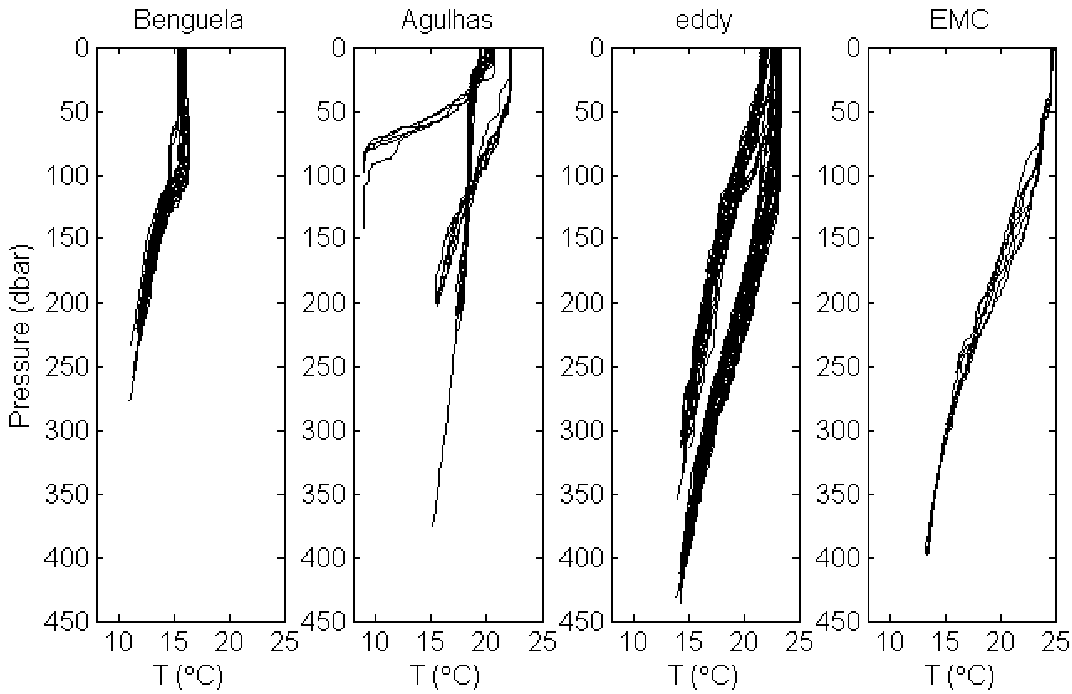

Fig. 5.7 Temperature Profiles

5.4.2 Thermosalinograph

(Rafael Abel, Laura Braby)

Sea surface temperature (SST) and sea surface salinity (SSS) were measured autonomously with a Thermosalinograph TSG3388 (S/N 2173416) that is located at the ship's head and 2m below the TSG close to the ship's shell is a temperature sensor (SEETemp S/N 0667). The sample frequency is every 10 seconds.

For calibration separate water samples were taken from the TSG two hourly and were analyzed by the Salinometer. The calibration was done with the de-spiked with median calculation for 40 min blocks every 10 minutes to overcome large fluctuations during the stormy weather. The calibration for salinity against sample salinity was done using a least mean square fit technique. A linear fit against time was applied and resulted in a RMS (Root Mean Square) misfit of 0.015 which is the assumed accuracy of the TSG data after calibration. In Figure 5.8 one can see that the calibration removed a rather significant offset that is also time dependent.

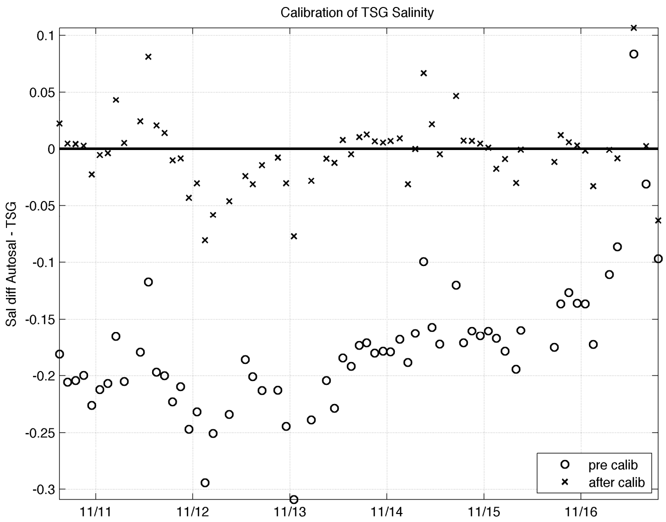

Fig. 5.8 Salinity difference between TSG and Autosal measurements as a function of time.

	Coefficients
RMS misfit after calibration - salinity	0.015
Polynomial coefficients – salinity (used day of the month as time axis)	Offset: -0.25004 time1: 0.010462

Results

Results from the thermosalinograph indicate an increase in temperature from 12°C to 25°C over the course of the cruise. Temperatures increase as one moves away from cooler upwelling water into the Indian Ocean. A spike in temperature occurred over the Agulhas Current from 10 October until 12 October and continued to increase towards Madagascar. Salinities also increase from 04 October until 15 October. A sharp drop in salinity occurred from 15- 16 October when the ship moved through and eddy. Salinity values remained low after this as the ship moved through the South East Madagascar Current.

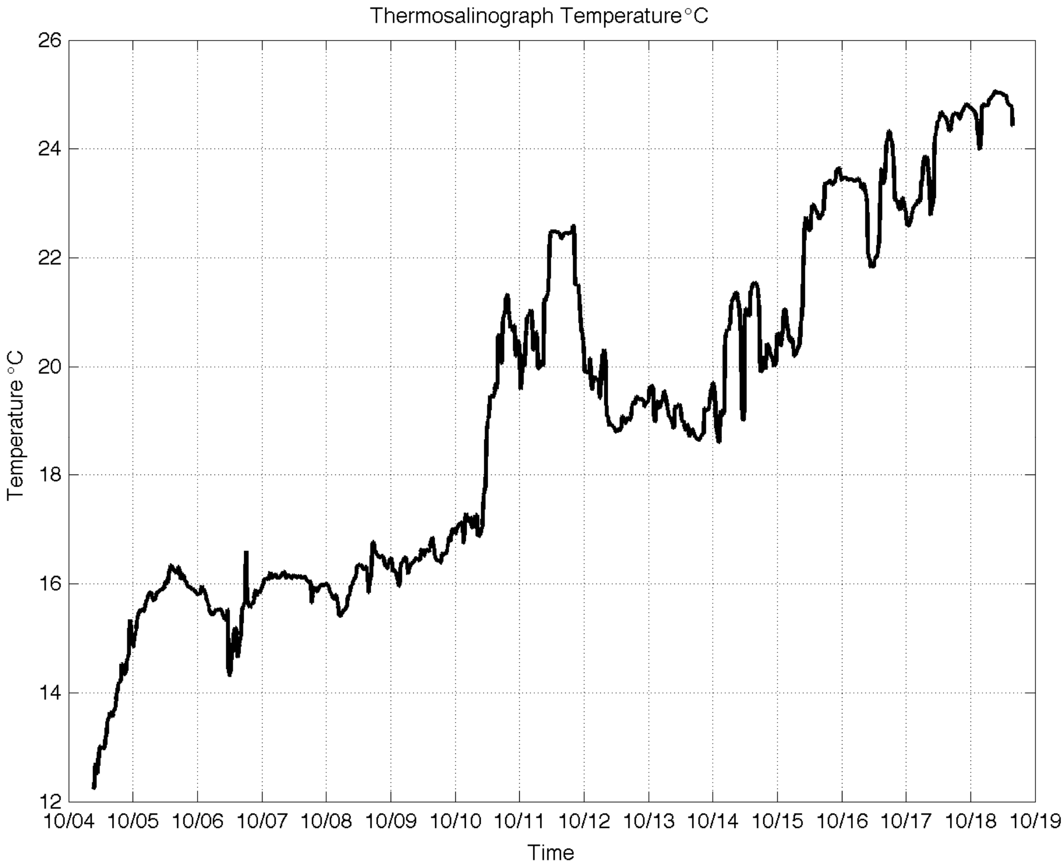

Fig. 5.9 Evolution of the sea surface temperature during the course of the cruise.

5.4.3 Trace gases

(Tim Rixen, Victor Libuku, Saskia Horstmann, Valerie Menke, Daniel Schult, Amelie Hagen, Mashifane Thulwaneng)

During the cruise M100/2 four underway systems were operated: SUNDANS (#001), G2201-i (1510CFIDS2047_v1.0), G1301 (CFADO-96), and a Ferry Box. The "SUrface UNderway carbon Dioxide partial pressure ANalySer, SUNDANS" developed by the company "marine analytics and data; MARIANDA" in Kiel is equipped with IR-sensor (LICOR, LI-7000) to measure xCO_2 in water as well as other parameters required to convert x into pCO_2 such as the atmospheric pressure and the temperature within the equilibrator (EQU). In addition to SUNDANS, a cavity ringdown spectrometer (Picarro G2201-i) was attached to the equilibrator and measured in an alternating mode xCO_2 in water (via the equilibrator) and directly in the atmosphere (Fig. 5.10). In addition to the G2201-i and second cavity ringdown spectrometer (Picarro G1301) from the Max Planck Institute of Biogeochemistry in Jena, Germany was used to measure exclusively concentrations of CO_2 and CH_4 in the atmosphere.

Sea surface temperatures (SST) and salinities which in addition to the air pressure are required to transform x into pCO_2 were measured by a Ferry-Box. The Ferry-Box is equipped with a "SBE45 Micro TSG" as well as with an "AANDERA Oxygen Optode 3830" and a pH sensor. The pCO_2 and the pH will allow us, in principle, to determine all parameters of the carbonate system such as the carbonate ion concentrations, the aragonite, and calcite saturation states. This data are of special interest for the discussion about ocean acidification and will be compared to foraminifera and pteropods counts from Valerie Menke and Nina Lester (UCT). Wind speeds required to calculate air sea fluxes of CO_2 were measured by the German Meteorological Service (DWD) and were provided via the DSHIP system to all scientists on board. Sea water temperatures (SST) and salinity data, which were measured by the thermosalinograph (TSG) were also distributed via the same DSHIP system (Fig. 5.10).

In order to calibrate the AANDERA Oxygen Optode 3830 and later on also the pH sensor, water samples were taken underway for determining the oxygen concentrations and the total alkalinity (TA). In total 46 oxygen and 42 TA samples were collected. Oxygen concentrations were determined by using the Winkler-titration method and an automatic TA-titration stand (VINDTA2C) developed by MARIANDA was used for the determination of TA. As soon as all corrections will be applied to xCO_2 and the correct pCO_2 values will be available, TA and pCO_2 will be used to calculate the pH. The calculated and the measured pH will then be compared to each other.

No	Parameter	Methods					
		G1301	G2201-i	SUNDANS	FerryBox	DSHIP	Titration
	Atmosphere						
1	xCO_2	X	X				
2	$\delta^{13}C_{CO2}$		X				
3	xCH_4	X	X				
4	$\delta^{13}C_{CH4}$		X				
5	Pressure			X		X	
6	Wind direction					X	
7	Wind speed					X	
	Water						
8	xCO_2		X	X			
9	$\delta^{13}C_{CO2}$		X				
10	xCH_4		X				
11	$\delta^{13}C_{CH4}$		X				
12	SST				X	X	
13	Salinity				X	X	
14	Oxygen				X		X
15	EQ-Temp.			X			
16	pH				X		
17	TA						X

Tab. 5.6 Within this table the measured parameters and the applied methods are listed.

Altogether we measured 17 parameters by using four different underway systems and applied additionally two wet-chemical methods for validation of sensors (Tab. 5.6). During the cruise tasks were distributed among the students as described in table 5.7.

The data measured by the different sensors correlate to each other (Fig. 5.7). However, the comparison of the different SST sensors shows substantial deviations between DSHIP and Ferry Box data during the Julian days 279 and 281 (Fig. 5.7). At that time we faced stormy weather conditions off South Africa in the Benguela Upwelling System. The heavy sea in the course of which air was sucked into the system probably caused the instability of the TSG (DSHIP). The water supply by the pump in the moon pool remained unaffected and the data measured by EQU and the Ferry-Box were stable at that period. However, at sea water temperatures > 20°C the temperature in the equilibrator (EQU) started to deviate by < 1.5° from the TSG and the Ferry-Box SSTs due to warming of the ocean and air condition in the lab. Within the Ferry Box the Seabird CTD (P/N90654-S/N0021) measures temperatures and salinities. The Seabird salinity data reveal on offset of 0.41 compared to the TSG salinities, which will be corrected by using the calibrated TSG data.

No	Parameter	Methods					
		G1301	G2201-i	SUNDANS	FerryBox	DSHIP	Titration
1	Victor Libuku	X	X	X			X(TA)
2	Saskia Horstmann			X			
3	Valerie Menke					X	
4	Mashifane Thulwaneng						X(O_2)
5	Amelie Hagen				X		
6	Daniel Schult		X				

Table 5.7 Distribution of tasks among the students.

Exemplary Results

In general the new gained data from this cruise supports our hypothesis, which based on so far only very little data from the south, suggests that the southern in contrast to the northern Benguela Upwelling Systems acts as CO_2 sink to the atmosphere. The first and still invalidated data on CH_4 concentrations in the atmosphere and the ocean along the South African coast imply that both, the northern and the southern Benguela Upwelling System as well the wider Agulhas region in the Indian Ocean act as CH_4 source to the atmosphere (Fig. 5.10). The stable isotopic composition of CO_2 and CH_4 in conjunction with the oceanographic data sets obtained during this cruise will further be analyzed in order to gain a better understanding of processes controlling greenhouse gas emissions along continental margins, and especially of those which are affected by strong western and eastern boundary currents.

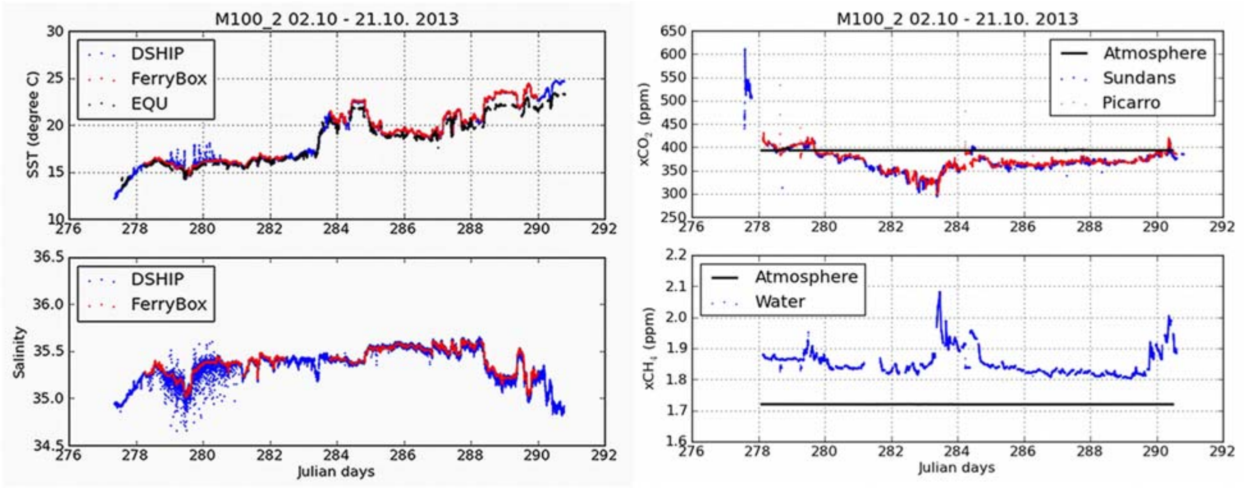

Figure 5.10 Left panel: Sea surface temperatures measured by the TSG (DSHIP), the Ferry-Box and within the equilibrators (EQU, SUNDANS) as well as salinities measured by TSG (DSHIP) and the Ferry-Box. Right panel: xCO2 determined by SUNDANS and the G2201-i as well as xCH4 measured by the G2201-i.

5.5 Weather conditions during M100/2

(Hartmut Sonnabend, Meteorological Office RV METEOR)

As scheduled RV METEOR left the harbour of Walvis Bay/Namibia in the morning 4th of October 2013 heading southwest towards the start point of the first transect off the coast of Namibia. Unfortunately very bad weather conditions dominated the first 4 days of this expedition. After a subdued overture during departure time the southeast trade wind started to increase very soon reaching force 6 Bft. until early noon with gusts up to Bft. 7 associated by a rough sea rising up to 2,5 – 3 meters. The reason for these uncomfortable conditions was due to a very frequent synoptic situation for this region. A strong anticyclone with a maximum air pressure of about 1033 hPa moved from the sea areas northeast of Gough Island towards the Cape Peninsula producing a sharp air pressure gradient like a bottleneck between the high in the southwest and a nearly stationary flat trough over the southern Africa and along the coastlines of Angola and Namibia. The following day brought a further deterioration, when the wind increased to force 7 with gusts up to 8 Bft. Maximum wind speed was reached during the night to 6.10., nearly lasting threw the whole day with an average wind force around Bft. 8 gusting up to 9-10 Bft. The sea state became very rough with wave heights around 5 meters and peak waves up to 6 - 7 meters. Due to this harsh development and for safety reasons the scientific measurements along the zonal transect had to be aborted and RV METEOR started to sail towards the next transect off the coast of East London/South Africa.

Persisting strong to stormy winds and very rough sea from ahead caused tough going at first, and these conditions normalized only very slowly from evening of 7.10. and threw the following night. Until morning of 8.10., when the centre of the “jointly responsible” anticyclone had surrounded the Cape Peninsula towards the Indian Ocean, the southeasterly wind decreased to Beaufort 6, allowing a significant increase in ships speed. This positive trend continued next day when RV METEOR reached and passed the sea areas west of the Cape Peninsula with a moderate to fresh breeze from the southeast and bright and sunny weather. Passing the axis of the remaining ridge of high pressure extending as a small belt between the subtropical centres over Southern Atlantic and Southern Indian Ocean, the wind calmed down more and more during 10.10. shifting to westerly and south-westerly directions until afternoon of this day.

As consequence of the fact that all available Global Forecast Models predicted very bad weather conditions with storm and high seas up to more than 6 meters on Saturday 12.10., it was decided to advance the next transect more south-westward with a starting position off the coast of Port Elizabeth instead of east London as intended before.

Being favoured by moderate to fresh winds from the aft the first station of that new defined transect was reached at noon of 11.10. As wind- and sea state conditions remained conducive this day, the first stations could have been carried out without any weather problems until late evening. The following night brought some gradual increase in wind speed up to 25 – 30 knots which means Bft. 6 – 7 from west to southwest. As wind sea wasn't developed fully until this time nearly all works could have been continued successfully inclusive the final station of this transect, when wind speed started to reach 28 – 34 knots = wind force 7 – 8 Bft. by early morning of 12.10., associated by a wind sea rising up to more than 3 meters.

Shortly after having finished all samplings and RV METEOR had started to set course towards the 3rd transect east of Madagascar, the wind increased rapidly to gale force 8 – 9 Bft. from west-southwest reaching gale force 9 by average around noon with maximum shower squalls up to 59 knots = Bft. 11, measured in the early afternoon. The wind sea became very rough mounting up until 6 – 7 meters by average. These spectacularly weather conditions were induced by a small but very intense trough embedded into the frontal zone in the south, passing the latitude of 40° south eastward, while a high pressure ridge from the South Atlantic Subtropical High started to spread eastward across the southernmost South Africa, producing a very sharp air pressure gradient between these two systems. After passage of the trough the wind shifted to southwest and south-southwest and gradually decreased to force 7 – 8 until evening of this day. During the following night and morning conditions normalized furthermore to south-westerly winds around Bft. 5 until afternoon of 13.10., allowing additional samplings in the evening. The last day of our interim stay in the transition area between the frontal zone in the south and a belt of high pressure in the north, 14th of October, brought one more slight increase of westerly to south-westerly winds up to 6 Bft. at first, shifting south-southwest and decreasing to force 5 later on.

Near the centre of a large high wandering eastward across the Subtropical South-western Indian Ocean, the wind calmed down to force 3 for some hours during morning of 15.10., before shifting southeast and increasing to a fresh to strong breeze later on this day, which marked the re-entrance into the South Hemispheric trade wind system. Approaching the sea areas off the southern most tip of Madagascar, the wind gradually shifted to easterly directions during 16th of October and to north-easterly directions while cruising along the South East coast one day later. A strong air pressure gradient between a ridge from the subtropical high extending towards the east coast of Madagascar and a flat trough over the western and south-western parts of this island kept the wind speed on a constant level of 20 – 25 knots on average until noon of 17th of October, followed by a slight decrease to northeast 5 Bft. during final approach towards the start point of the last transect, which was reached in the morning of 18.10. In the meantime the wind had decreased to a moderate northerly breeze, enabling good progress in station work until noon, and in spite of anew rise in wind speed during evening and late evening up to 22 – 25 knots on average from northeast, all works could have been completed successfully until early morning of 19.10. After having finished the last station RV METEOR set course towards Port Louis/Mauritius. The weather conditions on the last part of this cruise were mainly fine with a moderate to fresh wind from north-northeast to northeast at first and a gentle to moderate easterly breeze starting Sunday afternoon and lasting until arrival of RV METEOR at Port Louis in the morning 21.10.2013.

6 Outreach and Training Program

(Arne Biastoch and Martin Visbeck)

One of the objectives of the research cruise was to provide training for young scientists. 20 participants were marine sciences students from Germany, South Africa, Namibia, Mauritius and Madagascar. The available slots were advertised under the name of GATOR (German-African Training & Oceanographic Research) at southern African universities and research networks. 42 applications were received from African students, demonstrating a strong interest of young scientists in education of state-of-the-art methods in sea going marine research. The applications were ranked considering excellence and balance to give a broad range among disciplines and nationalities. The costs for the student participation were covered by a BMBF grant.

Regular lectures were held throughout the cruise (Tab. 6.1), covering a broad range topics in physical and biological oceanography and marine biogeochemistry. Owing to the wide background range of students, both in curricula (biology, chemistry and physical oceanography) and experience (BSc, MSc, PhD), lectures were given largely at an introductory level. Practicals and exercises, especially targeted for smaller groups, complemented the lectures and provided hands-on experience with oceanographic instruments, biological taxonomy, and analysis of model data.

Topic	**Lecturer**
Introduction to Physical Oceanography (7 lectures)	Martin Visbeck
Introduction to Numerical modeling (2 lectures)	Arne Biastoch
Introduction to Biogeochemistry (2 lectures)	Tim Rixen
Water Masses	Jenny Ullgren
The Agulhas Current System (2 lectures)	Arne Biastoch
The Benguela Upwelling System	Holger Auel
Introduction to Ichthyplankton	Nadine Strydom
Fish and Society	Nadine Strydom

Tab. 6.1 List of lectures.

All students participated in the collection of scientific measurements. They were assigned to be part of the twice per day watches (0-4, 4-8, 8-12), which were led by experienced scientists. Students were thus involved in all aspects of the handling of the instruments and nets as well as the calibration of instruments and analysis of water samples. This allowed them to gain insight and understanding of the individual methods of sea-going marine science. Several students were involved actively in producing the first scientific results from the cruise. The discussion of the scientific results and interpretation was seen as an important part in the educational character of this cruise.

At the beginning of the cruise, students were asked to cluster (optimally covering a range of nationalities and disciplines) in small groups to work on individual scientific projects. The students choose their own topics of interest. They varied, from highly interdisciplinary ideas in combining lobster larvae genetics with the observed and modeled ocean circulation, to more topical examples, such as measuring the sinking speed of copepod's fecal pellets, interpreting air-sea gas exchanges or water mass analysis. Students were given the opportunity to discuss and interact with the senior scientist and to learn from each other. All gained significant experiences in following through with interdisciplinary approaches. We had regular presentations of early findings. The final papers were presented orally and in written form towards the end of the cruise.

The occasion of cruise number M100 was used to issue a press release including a reference to the history of German marine sciences in the region. Individual impressions from scientists were also released in a blog portal (http://oceanblogs.org). Finally, video footages were taken throughout the cruise, to provide material for upcoming contributions to "GEOMAR TV".

7 Station List M100/2

Station No. M100/2_	Date Oct. 2013	Gear	Time	Latitude	Longitude	Station Depth m	Remarks
1936-1	4	CTD/rosette	12:28	23° 12.44' S	13° 54.74' E	130	T, S, P, O2, FL, Currents
1937-1	4	Hand net	12:36	23° 12.44' S	13° 54.74' E	30 - 0	Foraminifera
1938-1	4	Multiple net	12:52	23° 12.44' S	13° 54.74' E	150 - 0	Vertical haul
1939-1	4	Hand net	13:09	23° 12.43' S	13° 54.76' E	30 - 0	Foraminifera
1942-1	5	CTD - underway	07:30	24° 51.86' S	11° 26.81' E	200	T, S, P – probe 1
1942-1	5	CTD - underway	07:40	24° 52.91' S	11° 25.49' E	200	T, S, P – probe 1
1942-1	5	CTD - underway	07:55	24° 54.43' S	11° 23.32' E	200	T, S, P – probe 1
1942-1	5	CTD - underway	08:10	24° 55.91' S	11° 21.10' E	200	T, S, P – probe 1
1943-1	5	CTD/rosette	09:00	24° 59.99' S	11° 14.97' E	1000	T, S, P, O2, FL, Currents
1944-1	5	Hand net	09:01	24° 59.99' S	11° 14.97' E	30 - 0	Foraminifera
1945-1	5	Multiple net	10:16	24° 59.99' S	11° 14.97' E	800 - 0	Vertical haul
1946-1	5	Multiple net	11:16	25° 0.08' S	11° 14.76' E	2400 - 0	Vertical haul
1947-1	5	CTD - underway	12:14	25° 3.49' S	11° 17.23' E	200	T, S, P – probe 2
1947-1	5	CTD - underway	12:27	25° 4.84' S	11° 18.28' E	200	T, S, P – probe 2
1947-1	5	CTD - underway	12:40	25° 6.12' S	11° 19.30' E	200	T, S, P – probe 2
1947-1	5	CTD - underway	12:57	25° 7.80' S	11° 20.59' E	200	T, S, P – probe 2
1947-1	5	CTD - underway	13:06	25° 8.68' S	11° 21.26' E	200	T, S, P – probe 2
1947-1	5	CTD - underway	13:20	25° 10.12' S	11° 22.34' E	200	T, S, P – probe 2
1948-1	5	CTD/rosette	14:15	25° 14.98' S	11° 25.98' E	1000	T, S, P, O2, FL, Currents
1949-1	5	Hand net	14:23	25° 14.98' S	11° 25.98' E	30 - 0	Foraminifera
1950-1	5	Multiple net	15:04	25° 14.99' S	11° 25.96' E	800 - 0	Vertical haul
1951-1	5	CTD - underway	16:11	25° 15.77' S	11° 26.56' E	200	T, S, P – probe 2
1951-1	5	CTD - underway	16:24	25° 16.99' S	11° 27.46' E	200	T, S, P – probe 2
1951-1	5	CTD - underway	16:37	25° 18.17' S	11° 28.33' E	200	T, S, P – probe 2
1951-1	5	CTD - underway	16:49	25° 19.26' S	11° 29.12' E	200	T, S, P – probe 2
1951-1	5	CTD - underway	17:04	25° 20.58' S	11° 30.09' E	200	T, S, P – probe 2
1951-1	5	CTD - underway	17:15	25° 21.62' S	11° 30.86' E	200	T, S, P – probe 2
1951-1	5	CTD - underway	17:28	25° 22.77' S	11° 31.70' E	200	T, S, P – probe 2
1951-1	5	CTD - underway	17:41	25° 23.84' S	11° 32.48' E	200	T, S, P – probe 2
1951-1	5	CTD - underway	17:52	25° 24.74' S	11° 33.14' E	200	T, S, P – probe 2
1951-1	5	CTD - underway	18:05	25° 25.76' S	11° 33.89' E	200	T, S, P – probe 2
1951-1	5	CTD - underway	18:20	25° 27.07' S	11° 34.85' E	200	T, S, P – probe 2
1951-1	5	CTD - underway	18:34	25° 28.26' S	11° 35.72' E	200	T, S, P – probe 2
1951-1	5	CTD - underway	18:52	25° 29.76' S	11° 36.82' E	200	T, S, P
1951-1	5	CTD - underway	19:35	25° 33.13' S	11° 39.30' E	200	T, S, P – probe 1
1951-1	5	CTD - underway	19:46	25° 33.97' S	11° 39.91' E	200	T, S, P – probe 1
1951-1	5	CTD - underway	19:58	25° 34.88' S	11° 40.58' E	200	T, S, P – probe 1
1951-1	5	CTD - underway	20:09	25° 35.70' S	11° 41.18' E	200	T, S, P – probe 1
1951-1	5	CTD - underway	20:18	25° 36.34' S	11° 41.65' E	200	T, S, P – probe 1
1951-1	5	CTD - underway	20:27	25° 37.02' S	11° 42.15' E	200	T, S, P – probe 1
1951-1	5	CTD - underway	20:37	25° 37.74' S	11° 42.68' E	200	T, S, P – probe 1
1952-1	11	CTD - underway	04:34	34° 34.73' S	25° 1.68' E	105	T, S, P – probe 2

Station No. M100/2_	Date Oct. 2013	Gear	Time	Latitude	Longitude	Station Depth m	Remarks
1952-1	11	CTD - underway	04:44	34° 34.34' S	25° 4.01' E	105	T, S, P – probe 2
1952-1	11	CTD - underway	04:53	34° 34.00' S	25° 6.11' E	105	T, S, P – probe 2
1952-1	11	CTD - underway	05:01	34° 33.69' S	25° 8.00' E	105	T, S, P – probe 2
1952-1	11	CTD - underway	05:10	34° 33.34' S	25° 10.16' E		Cast Cancelled
1952-1	11	CTD - underway	05:32	34° 32.50' S	25° 15.32' E	150	T, S, P – probe 2
1953-1	11	CTD/rosette	09:14	34° 25.19' S	25° 59.96' E	310	T, S, P, O2, FL
1954-1	11	Hand net	09:16	34° 25.20' S	25° 59.93' E	30 - 0	Foraminifera
1955-1	11	Bongo net	09:38	34° 25.23' S	25° 59.82' E	200 - 0	Double-oblique haul
1956-1	11	CTD/rosette	12:18	34° 32.75' S	26° 8.44' E	1655	T, S, P, O2, FL, Currents
1957-1	11	Hand net	12:19	34° 32.77' S	26° 8.37' E	30 - 0	Foraminifera
1958-1	11	Bongo net	13:48	34° 34.61' S	26° 3.70' E	7 - 0	Double-oblique haul
1958-1	11	Bongo net	14:06	34° 34.70' S	26° 1.81' E	7 - 0	Double-oblique haul
1959-1	11	CTD - underway	15:05	34° 37.10' S	26° 3.84' E	200	T, S, P – probe 1
1959-1	11	CTD - underway	15:20	34° 37.47' S	26° 6.18' E	200	T, S, P – probe 1
1959-1	11	CTD - underway	15:35	34° 37.86' S	26° 8.57' E	200	T, S, P – probe 1
1959-1	11	CTD - underway	15:44	34° 38.09' S	26° 10.02' E	200	T, S, P – probe 1
1959-1	11	CTD - underway	15:56	34° 38.40' S	26° 11.97' E	200	T, S, P – probe 1
1959-1	11	CTD - underway	16:10	34° 38.77' S	26° 14.29' E	200	T, S, P – probe 1
1959-1	11	CTD - underway	16:20	34° 39.04' S	26° 15.97' E	200	T, S, P – probe 1
1960-1	11	CTD/rosette	16:50	34° 39.54' S	26° 19.98' E	2480	T, S, P, O2, FL, Currents
1961-1	11	Hand net	16:50	34° 39.54' S	26° 19.98' E	30 - 0	Foraminifera
1962-1	11	Bongo net	18:28	34° 40.40' S	26° 18.04' E	200 - 0	Double-oblique haul
1963-1	11	CTD - underway	19:35	34° 42.30' S	26° 21.37' E	200	T, S, P
1963-1	11	CTD - underway	19:50	34° 43.63' S	26° 23.95' E	200	T, S, P
1963-1	11	CTD - underway	20:03	34° 44.82' S	26° 26.25' E	200	T, S, P
1964-1	11	CTD/rosette	20:32	34° 46.81' S	26° 30.01' E	2000	T, S, P, O2, FL, Currents
1965-1	11	CTD - underway	22:20	34° 50.97' S	26° 33.71' E	200	T, S, P – probe 1
1965-1	11	CTD - underway	22:31	34° 52.05' S	26° 35.53' E	200	T, S, P – probe 1
1965-1	11	CTD - underway	22:45	34° 53.46' S	26° 37.88' E	200	T, S, P – probe 1
1965-1	11	CTD - underway	23:00	34° 54.98' S	26° 40.41' E	200	T, S, P – probe 1
1965-1	11	CTD - underway	23:14	34° 56.40' S	26° 42.79' E	200	T, S, P – probe 1
1965-1	11	CTD - underway	23:26	34° 57.61' S	26° 44.82' E	200	T, S, P – probe 1
1966-1	12	CTD/rosette	00:12	35° 1.19' S	26° 50.03' E	2000	T, S, P, O2, FL, Currents
1967-1	12	CTD - underway	02:03	35° 4.20' S	26° 52.64' E	200	T, S, P-probe
1967-1	12	CTD - underway	02:11	35° 5.03' S	26° 53.99' E	200	T, S, P – probe 2
1967-1	12	CTD - underway	02:26	35° 6.61' S	26° 56.55' E	200	T, S, P – probe 2
1967-1	12	CTD - underway	02:37	35° 7.78' S	26° 58.43' E	200	T, S, P – probe 2
1967-1	12	CTD - underway	02:48	35° 8.93' S	27° 0.30' E	200	T, S, P – probe 2
1967-1	12	CTD - underway	02:59	35° 10.09' S	27° 2.16' E	200	T, S, P – probe 2
1967-1	12	CTD - underway	03:15	35° 11.80' S	27° 4.85' E	200	T, S, P – probe 2
1967-1	12	CTD - underway	03:27	35° 13.18' S	27° 6.68' E	200	T, S, P – probe 2
1968-1	12	CTD/rosette	03:55	35° 15.59' S	27° 10.08' E	2000	T, S, P, O2, FL, Currents
1969-1	13	CTD/rosette	17:52	32° 57.30' S	33° 55.34' E	200	T, S, P, O2, FL, Currents

Station No. M100/2_	Date Oct. 2013	Gear	Time	Latitude	Longitude	Station Depth m	Remarks
1970-1	13	Hand net	17:54	32° 57.31' S	33° 55.35' E	30 - 0	Foraminifera
1971-1	13	Bongo net	18:11	32° 57.34' S	33° 55.33' E	200 - 0	Double-oblique haul
1972-1	15	CTD - underway	15:00	28° 43.76' S	42° 4.14' E	310	T, S, P – probe 2
1972-1	15	CTD - underway	15:14	28° 42.64' S	42° 6.61' E	410	T, S, P – probe 2
1972-1	15	CTD - underway	15:33	28° 41.11' S	42° 9.98' E	410	T, S, P – probe 2
1972-1	15	CTD - underway	16:17	28° 37.51' S	42° 17.90' E	410	T, S, P – probe 2
1972-1	15	CTD - underway	16:41	28° 35.59' S	42° 22.11' E	410	T, S, P – probe 2
1972-1	15	CTD - underway	17:04	28° 33.76' S	42° 26.13' E	410	T, S, P – probe 2
1972-1	15	CTD - underway	17:24	28° 32.19' S	42° 29.59' E	410	T, S, P – probe 2
1972-1	15	CTD - underway	17:43	28° 30.69' S	42° 32.89' E	410	T, S, P – probe 2
1972-1	15	CTD - underway	18:04	28° 29.01' S	42° 36.56' E	410	T, S, P – probe 2
1972-1	15	CTD - underway	18:42	28° 26.05' S	42° 43.08' E	410	T, S, P – probe 1
1972-1	15	CTD - underway	19:00	28° 24.67' S	42° 46.10' E	410	T, S, P – probe 1
1972-1	15	CTD - underway	19:19	28° 23.23' S	42° 49.26' E	410	T, S, P – probe 1
1972-1	15	CTD - underway	19:38	28° 21.80' S	42° 52.39' E	410	T, S, P – probe 1
1972-1	15	CTD - underway	19:57	28° 20.37' S	42° 55.54' E	410	T, S, P – probe 1
1972-1	15	CTD - underway	20:14	28° 19.09' S	42° 58.33' E	410	T, S, P – probe 1
1972-1	15	CTD - underway	20:32	28° 17.75' S	43° 1.27' E	410	T, S, P – probe 1
1972-1	15	CTD - underway	20:55	28° 16.03' S	43° 5.04' E	410	T, S, P – probe 2
1972-1	15	CTD - underway	21:16	28° 14.49' S	43° 8.42' E		Cast stopped early
1972-1	15	CTD - underway	21:37	28° 12.97' S	43° 11.74' E	410	T, S, P – probe 2
1972-1	15	CTD - underway	21:56	28° 11.59' S	43° 14.76' E	410	T, S, P – probe 2
1972-1	15	CTD - underway	22:52	28° 7.48' S	43° 23.77' E	410	T, S, P – probe 1
1972-1	15	CTD - underway	23:17	28° 5.66' S	43° 27.74' E	410	T, S, P – probe 1
1972-1	15	CTD - underway	23:50	28° 3.30' S	43° 32.91' E	410	T, S, P – probe 1
1972-1	16	CTD - underway	00:10	28° 1.88' S	43° 36.00' E	410	T, S, P – probe 1
1972-1	16	CTD - underway	01:09	27° 57.81' S	43° 44.91' E	410	T, S, P – probe 2
1972-1	16	CTD - underway	01:28	27° 56.51' S	43° 47.75' E	410	T, S, P – probe 2
1972-1	16	CTD - underway	01:45	27° 55.35' S	43° 50.27' E	410	T, S, P – probe 2
1972-1	16	CTD - underway	02:07	27° 53.87' S	43° 53.50' E	410	T, S, P – probe 2
1972-1	16	CTD - underway	02:24	27° 52.73' S	43° 56.01' E	410	T, S, P – probe 2
1972-1	16	CTD - underway	02:41	27° 51.58' S	43° 58.51' E	410	T, S, P – probe 2
1972-1	16	CTD - underway	03:00	27° 50.31' S	44° 1.27' E	410	T, S, P – probe 2
1972-1	16	CTD - underway	03:19	27° 49.05' S	44° 4.02' E	410	T, S, P – probe 2
1972-1	16	CTD - underway	03:39	27° 47.74' S	44° 6.88' E	410	T, S, P – probe 2
1972-1	16	CTD - underway	03:58	27° 46.52' S	44° 9.55' E	410	T, S, P – probe 2
1972-1	16	CTD - underway	04:16	27° 45.34' S	44° 12.13' E	410	T, S, P – probe 2
1972-1	16	CTD - underway	04:39	27° 43.82' S	44° 15.43' E	410	T, S, P – probe 2
1972-1	16	CTD - underway	05:08	27° 41.90' S	44° 19.61' E	410	T, S, P – probe 1
1972-1	16	CTD - underway	05:25	27° 40.76' S	44° 22.10' E	410	T, S, P – probe 1
1972-1	16	CTD - underway	05:43	27° 39.56' S	44° 24.72' E	410	T, S, P – probe 1
1972-1	16	CTD - underway	06:01	27° 38.36' S	44° 27.33' E	410	T, S, P – probe 1
1973-1	16	CTD - underway	08:15	27° 29.53' S	44° 46.56' E	310	T, S, P – probe 1

Station No. M100/2_	Date Oct. 2013	Gear	Time	Latitude	Longitude	Station Depth m	Remarks
1973-1	16	CTD - underway	08:28	27° 28.72' S	44° 48.32' E	310	T, S, P – probe 1
1973-1	16	CTD - underway	08:41	27° 27.88' S	44° 50.15' E	310	T, S, P – probe 1
1973-1	16	CTD - underway	08:53	27° 27.10' S	44° 51.84' E	310	T, S, P – probe 1
1973-1	16	CTD - underway	09:06	27° 26.23' S	44° 53.72' E	310	T, S, P – probe 1
1973-1	16	CTD - underway	09:35	27° 24.27' S	44° 57.99' E	310	T, S, P – probe 2
1973-1	16	CTD - underway	09:49	27° 23.31' S	45° 0.08' E	310	T, S, P – probe 2
1973-1	16	CTD - underway	10:03	27° 22.33' S	45° 2.21' E	310	T, S, P – probe 2
1973-1	16	CTD - underway	10:16	27° 21.40' S	45° 4.22' E	310	T, S, P – probe 2
1973-1	16	CTD - underway	10:29	27° 20.46' S	45° 6.26' E	310	T, S, P – probe 2
1973-1	16	CTD - underway	10:49	27° 19.01' S	45° 9.43' E	310	T, S, P – probe 2
1973-1	16	CTD - underway	11:11	27° 17.38' S	45° 12.96' E	310	T, S, P – probe 1
1973-1	16	CTD - underway	11:27	27° 16.17' S	45° 15.59' E	310	T, S, P – probe 1
1973-1	16	CTD - underway	11:41	27° 15.05' S	45° 18.01' E	310	T, S, P – probe 1
1973-1	16	CTD - underway	11:55	27° 13.94' S	45° 20.42' E	310	T, S, P – probe 1
1973-1	16	CTD - underway	12:15	27° 12.34' S	45° 23.91' E	310	T, S, P – probe 1
1973-1	16	CTD - underway	12:41	27° 10.34' S	45° 28.40' E	310	T, S, P (?)
1973-1	16	CTD - underway	12:55	27° 9.28' S	45° 30.84' E	310	T, S, P – probe 2
1973-1	16	CTD - underway	13:04	27° 8.61' S	45° 32.41' E	310	T, S, P – probe 2
1973-1	16	CTD - underway	13:23	27° 7.18' S	45° 35.71' E	310	T, S, P – probe 2
1973-1	16	CTD - underway	13:37	27° 6.13' S	45° 38.13' E	310	T, S, P – probe 2
1973-1	16	CTD - underway	13:50	27° 5.18' S	45° 40.34' E	310	T,S,P, Stopwatch error
1973-1	16	CTD - underway	14:03	27° 4.24' S	45° 42.51' E	335	T, S, P – probe 2
1973-1	16	CTD - underway	14:18	27° 3.14' S	45° 45.06' E	360	T, S, P – probe 2
1973-1	16	CTD - underway	14:32	27° 2.12' S	45° 47.42' E	310	T, S, P – probe 2
1973-1	16	CTD - underway	14:47	27° 1.04' S	45° 49.90' E	310	T, S, P – probe 2
1974-1	18	CTD/rosette	00:00	22° 59.86' S	47° 57.80' E	200	T, S, P, O2, FL, Currents
1975-1	18	Hand net	00:10	22° 59.88' S	47° 57.78' E	30 - 0	Foraminifera
1976-1	18	Bongo net	00:24	22° 59.93' S	47° 57.75' E	200 - 0	Double-oblique haul
1977-1	18	CTD/rosette	04:22	22° 43.04' S	48° 7.97' E	1530	T, S, P, O2, FL, Currents
1978-1	18	Hand net	04:28	22° 43.17' S	48° 7.90' E	30 - 0	Foraminifera
1979-1	18	Bongo net	05:26	22° 43.96' S	48° 7.44' E	200 - 0	Double-oblique haul
1980-1	18	CTD - underway	06:24	22° 44.64' S	48° 7.29' E	310	T, S, P – probe 2
1980-1	18	CTD - underway	06:41	22° 44.87' S	48° 10.20' E	310	T, S, P – probe 2
1980-1	18	CTD - underway	06:52	22° 45.00' S	48° 12.18' E	310	T, S, P – probe 2
1980-1	18	CTD - underway	07:05	22° 45.14' S	48° 14.49' E	310	T, S, P – probe 2
1981-1	18	CTD/rosette	07:35	22° 45.47' S	48° 18.43' E	2900	T, S, P, O2, FL, Currents
1982-1	18	CTD - underway	09:29	22° 46.18' S	48° 19.91' E	410	T, S, P – probe 2
1982-1	18	CTD - underway	09:44	22° 46.77' S	48° 22.53' E	410	T, S, P – probe 2
1982-1	18	CTD - underway	10:04	22° 47.50' S	48° 25.96' E	410	T, S, P – probe 2
1983-1	18	CTD/rosette	10:35	22° 47.83' S	48° 28.77' E	2000	T, S, P, O2, FL, Currents
1984-1	18	Bongo net	11:58	22° 47.71' S	48° 28.95' E	150 - 0	Double-oblique haul
1985-1	18	CTD - underway	12:36	22° 47.85' S	48° 30.76' E	410	T, S, P – probe 2
1985-1	18	CTD - underway	12:54	22° 48.88' S	48° 33.77' E	410	Record not clear

Station No. M100/2_	Date Oct. 2013	Gear	Time	Latitude	Longitude	Station Depth m	Remarks
1986-1	18	CTD/rosette	13:46	22° 50.20' S	48° 39.19' E	2000	T, S, P, O2, FL, Currents
1987-1	18	CTD/rosette	16:08	22° 52.59' S	48° 49.58' E	2000	T, S, P, O2, FL, Currents
1988-1	18	CTD/rosette	18:36	22° 55.02' S	48° 59.99' E	2000	T, S, P, O2, FL, Currents
1989-1	18	CTD/rosette	20:56	22° 58.03' S	49° 9.96' E	2000	T, S, P, O2, FL, Currents

Note: U-CTD probe 1= serial number 0068, probe 2 = serial number 0155.

8 Data and Sample Storage and Availability

The data were collected from four different research groups (Kiel, Hamburg, Bremen, S. Africa). In Kiel a Datamanagement-Team is active, which stores the data in a webbased multi-user-system. In a first phase the data are only available to the participating groups. After an up to three year long proprietary time these data will be made public by distributing them to national and international data archives through the GEOMAR data management team. However, most of the data will be submitted to PANGAEA by October 2014. The data sets will be archived in the PANGAEA Open Access library and digital object identifiers (DOIs) will be assigned.

All meta-data are available here https://portal.geomar.de/metadata/leg/show/323316 . And a kml (Google Maps) link is here https://portal.geomar.de/metadata/leg/kmlexport/323316 .

Zooplankton samples from the MultiNet and from the 300 µm Bongo net were preserved in buffered 4% formaldehyde in seawater solution and will be stored at the BreMarE – Bremen Marine Ecology Centre of the University of Bremen. Geo-referenced data such as zooplankton biomass will be archived and made accessible through the GENUS – Geochemistry & Ecology of the Namibian Upwelling System data base, which is operated and accessible through the PANGAEA data base, at the end of 2017. Physiological data will be stored at BreMarE, University of Bremen. The South African initiative to collect Ichthyoplankton produced samples that will be archived in their data base in South Africa.

The collected underway geochemical data will be submitted after calibration to the GENUS database and later on to PANGAEA. GENUS (Geochemistry and Ecology of the Namibian Upwelling System) is a BMBF funded project within the SPACES program.

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10 References

During the cruise we followed the guide lines recently developed by the GO-SHIP group, particularly did we consider the guides for best practices:

Hood, E.M., C.L. Sabine, and B.M. Sloyan, eds. 2010. The GO-SHIP Repeat Hydrography Manual: A Collection of Expert Reports and Guidelines. IOCCP Report Number 14, ICPO Publication Series Number 134. Available online at http://www.go-ship.org/HydroMan.html.

Specific sections of the above GO-SHIP manual referred to in this report are:

Langdon, C. "Determination of Dissolved Oxygen in Seawater by Winkler Titration Using the Amperometric Technique."

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